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DEVELOPMENT DIGEST

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Patricia W. Blair, Editor; Pushpa Nand Schwartz, Associate Editor
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DEVELOPMENT PROJECTS OBSERVED

THE PRINCIPLE OF THE HIDING HAND

Albert O. Hirschman

[In the first chapter of his new book, Prof. Hirschman enunciates the "principle" that each project comes into the world accompanied by two sets of partially or wholly offsetting potential developments: a set of unsuspected threats to its existence, and a set of unsuspected remedial actions that can be taken should the threat become real.]

The Karnaphuli pulp and paper mill is one of the earliest large-scale industrial enterprises to have been set up in Pakistan after Independence. Planned by the official Industrial Development Corporation to utilize the vast resources of the bamboo forests of the Chittagong Hill Tracts along the upper reaches of the Karnaphuli River in East Pakistan, the mill started to operate in 1953. It had perhaps more than its share of technical and managerial teething troubles, but considerable progress had been achieved by 1959, when its management passed into private hands. Soon thereafter, a major upset endangered the very life of the mill: the bamboo began to flower, an event entirely unforeseen and probably unforeseeable in the present state of our knowledge about bamboo, since it occurs only once every fifty to seventy years. In any event, the variety that supplied the Karnaphuli mill with some 85 percent of its raw material flowered and then, poetically but quite uneconomically, died....

It was discovered that the bamboo that dies upon flowering is unusable for pulping since it would disintegrate upon being transported and floated down the river. Another unpleasant surprise was the discovery

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that, once flowering was over, a number of years would have to pass before new bamboo shoots would grow to a size fit for commercial exploitation. In its seventh year of operation the mill therefore faced the extraordinary task of finding another raw material base.

In a temporary and costly way, the problem was solved by importing pulp, but other, more creative responses were not long in coming. An organization was set up to collect bamboo in villages throughout East Pakistan (the waterways crisscrossing the country make for cheap transportation of bulky cargo), sundry lumber was cut in the tracts, and, most important, research was started to identify other fast-growing species that might to some extent replace the unreliable bamboo as the main raw material base for the mill. An experimental area of six square miles was planted with several of the more promising species, and plans to cover a much larger area are under way. Thus, the crisis of the flowering bamboo may in the end lead to a diversification of the mill's raw material base.

Looking back, it may be said that the Karnaphuli mill was "lucky": its planners badly overestimated the permanent availability of bamboo, but the mill escaped the possibly disastrous consequences of this error by an offsetting underestimate—or, more correctly, by the unsuspected availability—of alternative raw materials.

The question I wish to explore is whether this experience really was a matter of luck or whether there are reasons to expect some systematic association of such providentially offsetting errors. A similar phenomenon often occurs in successful irrigation-hydroelectric projects: the river that is being tapped is frequently found not to have enough water for all the power, agricultural, industrial, and urban uses that had been planned or are staking claims, but the resulting shortage can often be remedied by drawing on sources that had not been within the horizon of the planners: ground water can be lifted by tubewells, the river flow can be better regulated through upstream dams, or the water of more distant rivers can be diverted. At present such plans are afoot for the San Lorenzo irrigation scheme in Peru, and for the Damodar Valley in India, for example.

It would obviously be silly to expect that overestimates of the availability of a given material resource are always going to be offset by underestimates of alternative or substitute resources. But if we generalize a little more, we obtain a statement that no longer sounds wholly absurd. On the contrary, it is quite plausible, and almost trite, to state that each project comes into the world accompanied by two sets of partially or wholly offsetting potential developments: 1) a set of possible and unsuspected threats to its profitability and existence, and 2) a set of unsuspected remedial actions that can be taken should a threat become real.

The experience of several of the IBRD projects this author visited fits this very broad proposition. For example, the San Lorenzo irrigation project in northern Peru suffered serious, and at times exasperating, delays caused by political change and second thoughts on the kind of irrigation farming the project should promote. But the considerable economic losses implied by the delays were in part offset by the fact that, as a result of the second thoughts, the San Lorenzo irrigation eventually became a pilot project for the subdivision of land into small but viable family farms and for the granting of credit and technical assistance to previously landless farmers. The project thus set an entirely new pattern for Peruvian agriculture and turned unexpectedly into a breeding ground for administrators who could apply elsewhere in Peru the lessons learned in San Lorenzo.

The Uruguayan livestock and pasture improvement project also experienced extraordinary delays, first because of slowness in political and administrative decision making and then because the key technical task of improving the natural grasslands by introduction of legumes into the soil turned out to be unexpectedly complex. Yet the solutions that were gradually found through scientific research and practical experimentation and were then applied over an expanding area have now started to make this program into a particularly successful operation and have served to spread the spirit of innovation among a large group of Uruguayan farmers.

Somewhat similar sequences can be found in other projects, although the unhappy experience of the Nigerian Railway Corporation, which has steadily lost ground in competition with truck transport, serves as an emphatic warning that, by itself, trouble does not constitute a sufficient condition for a "creative response."

The common structure of the Pakistani, Peruvian, and Uruguayan projects can now be formulated as follows:

1. If the project planners (and this usually includes the international officials involved in financing the project) had known in advance all the difficulties and troubles that lay in store for the project, they probably would never have touched it, because a gloomy view would have been taken of the country's ability to overcome these difficulties by calling into play political, administrative, or technical creativity.

2. In some—though not all—of these cases, advance knowledge of these difficulties would have been unfortunate, for the difficulties and the ensuing search for solutions set in motion a train of events that not only rescued the project but often made it particularly valuable.

We may be dealing here with a general principle: Creativity always comes as a surprise to us; therefore we can never count on it and we dare not believe in it until it has happened. In other words, we would not consciously engage upon tasks whose success clearly requires that creativity be forthcoming. Hence, the only way we can bring our creative resources fully into play is by misjudging the nature of the task, by presenting it to ourselves as more routine, simple, undemanding of genuine creativity than it will turn out to be.

Or, put differently: since we necessarily underestimate our creativity, it is desirable that we underestimate to a roughly similar extent the difficulties of the tasks we face so as to be tricked by these two offsetting underestimates into undertaking tasks that we can, but otherwise would not dare, tackle. The principle is important enough to deserve a name: since we are apparently on the trail here of some sort of invisible or hidden hand that beneficially hides difficulties from us, I propose the Hiding Hand....

While some presence of the Hiding Hand may be helpful or required in eliciting action under all latitudes, it is no doubt specially needed where the tradition of problem-solving is weak and where invention and innovation have not yet been institutionalized or routinized. In other words, in developed countries less hiding of the uncertainties and likely difficulties of a prospective task is required than in underdeveloped countries where confidence in creativity is lacking.

We shall now explore in more detail the circumstances under which the Hiding Hand is likely to come into play. Which projects, in other words, tend to be undertaken because their difficulties are liable to be underestimated? And which tend to be neglected because their difficulties are too obvious? These questions make it evident that the Hiding Hand, while permitting an increase in the rate at which projects are taken up, also leads to a bias in project selection.

It is clear, for example, that projects derive a crucial advantage from being based on a technique that looks transferable even though it may not actually be nearly as copiable as it looks. This is perhaps a principal reason that infrastructural and industrial projects have so large an edge over others: not that the techniques involved are in fact so transferable; time and again industrial projects run into considerable technical and managerial difficulties when they are transplanted to a different environment. But factories look as though they could be picked up and dropped anywhere, whereas in activities like agriculture and education the need for adaptation and the concomitant problems are immediately obvious. Industry thus lends itself eminently to the operation of the Hiding Hand, whereas agricultural projects suffer from the abandon and sincerity with which they flaunt their prospective difficulties.

This conclusion is reinforced when the principle of the Hiding Hand is viewed in the perspective of time. For its mechanism to work, it is necessary that the operators be thoroughly "caught" by the time the unsuspected difficulties appear—caught in the sense that having spent considerable money, time, and energy, and having committed their prestige, they will be strongly motivated to generate all the problem-solving energy of which they are capable.

Just as the Hiding Hand principle states that the to-be-experienced difficulties should be hidden at the moment of the decision to go ahead with the project, so it implies that these difficulties should not appear too early after the execution of the project has started, for, at least within a certain range, the propensity to tackle the difficulties will be roughly proportional to the effort, financial and otherwise, already furnished. Therefore, a given level of difficulties may be wholly discouraging for the prosecution of the project if it turns up early, while it would be tackled with alacrity and perhaps solved if it arose at a later stage.

In spite of the somewhat paradoxical ring of this assertion—paradoxical only because medical science has impregnated us with the notion that the sooner a malady is recognized and diagnosed the better—it appears to be confirmed by experience with development projects, and it again underlines the disadvantageous position of agricultural as compared with industrial and infrastructural projects. With the important exceptions of irrigation and tree-crop projects, agricultural projects have a short gestation period and production or marketing difficulties unfold rather soon after the projects have been started; hence, attempts to rescue them are often half-hearted, and they are readily pronounced failures and abandoned. This is the story of many colonization projects in Latin America and Africa.

This difference between projects with short and long gestation periods is well illustrated by the contrasting fates of the East African Groundnut Scheme and the Owen Falls Hydroelectric Station in Uganda. Undertaken at the same time (in the immediate postwar period), in the same region, by the same kind of colonial administrators, both schemes were financially unsuccessful during their early years. The Groundnut Scheme was soon abandoned and hardly anything remains of it; the Owen Falls Station, on the other hand, had many lean years, but it endured and finally came into its own and will soon have to be supplemented by new generating capacity. Once it had become clear that the originally anticipated industrial boom in the Owen Falls area was not going to materialize, the Uganda Electricity Board made an effort to tap new markets for its power, building transmission lines to neighboring Kenya at first and then to a host of smaller industries and towns of Uganda.

The mere ability of the Owen Falls Station to survive cannot, of course, be taken as a vindication of the original investment decision. While later administrators were right in considering as bygone the heavy costs that had been sunk into the project in its early years, the project as a whole may still have to be given a poor mark. It is well known that with long-gestation projects one runs the risk that good money will be thrown after bad. We are here pointing out that short-gestation projects are subject to the opposite risk: the failure to throw good money after what looks bad, but could be turned into good, if only the requisite rescue effort were forthcoming.

The foregoing remarks permit a policy conclusion: Projects whose potential difficulties and disappointments are apt to manifest themselves at an early stage should be administered by agencies having a long-term commitment to the success of the projects. They should be developed as much as possible in an experimental spirit, in the style of a pilot project gathering strength and experience gradually, so that they may escape being classed and closed down as failures in their infancy. The Uruguayan livestock and pasture improvement project followed both these precepts and has thus been able to survive and to achieve maturity and success.

Servants of the Hiding Hand

Promoters and developers must long have been dimly aware of the Hiding Hand principle, for they have been remarkably adept at finding ways in which projects that would normally be discriminated against because they are too obviously replete with difficulties and uncertainties can be made to look more attractive to the decision maker.

One widely practiced method consists in pretending that a project is nothing but a straightforward application of a well-known technique that has been used successfully elsewhere, especially in an advanced country. For example, for a number of years after World War II, any river valley development scheme, whether it concerned the São Francisco River in Brazil, the Papaloapan River in Mexico, the Cauca in Colombia, the Dez in Iran, or the Damodar in eastern India, was presented to a reassured public as a true copy—if possible, certified expressly by David Lilienthal—of the Tennessee Valley Authority. Although, obviously, two river valley development schemes will differ vastly more from one another than two Coca Cola bottling plants, the impression was created, by the appeal to the "TVA model," that clear sailing lay ahead for the proposed schemes.

This attempt at making a project's path look smoother than it is may be termed the "pseudo-imitation" technique. When the novelty or difficulty of the task is too obvious for this technique to be

plausible, another method is often used. It consists in dismissing previous efforts at solving the task as "piecemeal" and in pretending to more insight than is actually available by drawing up a "comprehensive program."

An excellent example of this "pseudo-comprehensive-program" technique is supplied by the Uruguayan livestock and pasture improvement project. It started with the avowed aim of "implementing" a joint mission report issued in 1951 by the FAO and World Bank. The report's recommendations covered an extremely wide spectrum, as will appear from the following incomplete list of topics: fencing off of pastures; grazing trials; tree plantings; introduction of legumes; increased use of lime and phosphate; shrub eradication; works to control runoff water; better storage facilities; establishment of diversified farming combining harvested crops and livestock; improvement in irrigation, tillage practices, weed and pest control, erosion control, control of animal disease; improvement in transportation, storage, and marketing; organization of research and technical services; appropriate price and other economic policies.

Such a report tends to give the policy makers and project planners the illusion that all they need do is faithfully to "implement" the "experts'" multifarious recommendations. In fact, Uruguayan agriculture had shown prolonged resistance to many of the report's proposals, which were by no means new; it still requires considerable and difficult breakthroughs in technical, organizational, and other realms. But the comprehensive-program technique underplays this need for imagination, insight, and application of creative energies, and the project planners are, as it were, tricked into undertaking a program whose real difficulties will only gradually become apparent to them....

Real interdependencies exist, no doubt, and a multipronged attack on a problem is often necessary. But a comprehensive program that stems from real insight into the problem will be easy to distinguish from one that is a smoke screen for ignorance, for in the former the nature of the interdependencies will be clearly spelled out and an effort will have been made, in the interests of feasibility, to limit the number of activities that have to be undertaken concurrently. This sort of minimization of balanced growth requirements which has all the marks of insight into the problem was evident in a 1964 plan for creating an industrial "pole" in the Taranto-Bari-Brindisi area in southern Italy: a deliberate effort was made to determine a strictly limited number of establishments producing intermediate goods and providing services, such as tool making, that would have to be available if a certain group of newly planned mechanical industries were to find it attractive to locate at the pole.

Regional development programs supply additional illustrations that certain comprehensive programs function, in effect, as "servants" of the Hiding Hand. Here, too, the programs traced out in advance must be as multifarious as possible to build up the morale of the slightly frightened decision makers; for, in addition to overcoming their ignorance about the path to progress for their region or valley, they must do battle with various powerful contrary interests and must therefore form as broad a coalition as possible by promising something to every important section within the region or valley....

The two purveyors of the Hiding Hand—the pseudo-imitation technique and the pseudo-comprehensive-program technique—are nicely complementary: the former makes projects appear less difficulty-ridden than they really are, whereas the latter gives the project planners the illusion that they are in possession of far more insight into the projects' difficulties than is as yet available. Both techniques act essentially as crutches for the decision maker, permitting him to go forward at a stage when he has not yet acquired enough confidence in his problem-solving ability to make a more candid appraisal of a project's prospective difficulties and of the risks he is assuming.

The Hiding Hand is essentially a mechanism that makes the risk-averter take risks and in the process turns him into less of a risk-averter. In this manner, it opens an escape from one of those formidable "prerequisites" or "preconditions" to development; it permits the so-called prerequisite to come into existence after the event to which it is supposed to be the prerequisite. In our model, risk-taking behavior is engaged in actively (though involuntarily) prior to the arrival on the stage of the "risk-taking, achievement-motivated personality"; instead, it is this personality that is fashioned by risk-taking behavior. Recourse to the Hiding Hand thus becomes less necessary as development proceeds, for one of the indirect benefits of projects is precisely that the willingness of the decision maker to face uncertainty and difficulty is increased....

Something must now be said about the dangers and failures of the Hiding Hand. The Hiding Hand is essentially a transition mechanism through which decision makers learn to take risks, and the shorter the transition and the faster the learning the better. For this mode of learning about risk is not without grave dangers. One has to be rather lucky to be lured by the Hiding Hand into ventures whose emergent problems and difficulties can be successfully tackled. As long as one needs this "crutch" in order to act, the probability of committing major errors and of undertaking projects that will turn into failures is obviously higher than when one is able to differentiate between acceptable and non-acceptable risk.

Moreover, those servants of the Hiding Hand—the pseudo-imitation and the pseudo-comprehensive-program techniques—have hardly been described in flattering terms. One reason is precisely that they can easily be habit-forming rather than self-liquidating. The camouflage they use to disguise pioneering entrepreneurship may go undetected for a long time and may continue to be used when it is no longer needed. Moreover, these techniques have a number of undesirable side effects. The pseudo-imitation technique will not permit a country to reap the full psychological benefit of the ventures successfully launched under its auspices, since there will remain a lingering feeling that any achievement is due to the imitation of a foreign model. The pseudo-comprehensive-program technique may, even after a favorable outcome, leave a sense of disappointment and frustration; for, a number of measures and objectives that were once important elements in the "comprehensive program" will no longer be actively pursued once the most promising approach is discovered. As a result, public opinion will tend to lament the abandonment of originally much touted programs, and the project, even though a success, will leave behind a vague sense of failure....

Overestimation of Benefits

Exaggeration of prospective benefits is at least as common a device to elicit action as underestimation of costs. This error, specially when it is combined with an underestimate of costs, has of course often led to disaster. History abounds with examples, from bankruptcies and white elephants to lost or ruinously won wars. But just as the hiding of costs, the exaggeration of benefits can occasionally serve to ward off another, less visible, but nonetheless real, disaster—missed opportunity.

This is the case when difficulties in the project's path are unhideable. Take, for example, projects that clearly require the making of politically difficult decisions such as a change in existing administrative structures around which considerable vested interests have gathered. This was the case of the Damodar Valley Corporation, whose basic charter meant surrender of important powers of the states of West Bengal and Bihar (and to some extent also of the central government) to the new agency. To justify so unprecedented a move, it became necessary for the promoters of the agency to make such extravagant claims as that it would transform the Damodar Valley into "India's Ruhr" or that it would promote rapid, harmonious, and integrated development of all of the valley's natural and human resources, when in effect its task was rather narrowly limited to flood control, electric power generation, and some irrigation. The promise of some sort of utopia is most characteristic of larger-scale undertakings such as the launching of social reforms or of external aggression because they are likely to require heavy initial sacrifices.

At times, a more sweeping, utopian vision may be necessary not so much to offset the inflated costs of the proposed enterprise as to compensate for an infirmity of man's imagination; for even though costs may not appear unduly high, man may simply be unable to conceive of the strictly limited, yet satisfactory, advances, replete with compromises and concessions to opposing forces, which are the very stuff of "incremental politics" as well as the frequent result of ambitious socioeconomic development moves. The Damodar Valley story furnishes a good illustration for this kind of development: from the early fifties on, the Damodar Valley Corporation was increasingly hemmed in by encroachments on its original powers by the states of West Bengal and Bihar, and little remained in the mid-1960's of the majestic vision of integrated development of the valley's resources under the agency's unified command; yet the contribution of the agency's installations to industrial, urban, and resource development has fully justified the major portion of the investments the agency undertook, and it is doubtful that these investments would have been made without the stimulus of the initial vision.

We have now identified two situations in which overestimates of benefits can play a positive role: 1) when, because of inexperience in problem-solving, the actors have an exaggerated idea of the costs and difficulties of action, and 2) when, because of inexperience with the actual processes of change, the actors are unable to visualize intermediate outcomes and limited advances. As in the case of the Hiding Hand with its underestimate of costs and difficulties, and pending the correction of these various inexperiences, the overestimate of benefits must therefore be recognized as a useful development mechanism for a transitional phase.

But, for the reasons already given, it is much to be desired that this transitional phase be short. The very description-exposé of these mechanisms of self-deception that has been attempted here may persuade project planners to dispense with these crutches as soon as it is possible for them to do so. A more effective cure could come with improved knowledge of various aspects of project behavior. To acquire elements of such knowledge is the purpose of the next chapters.

EDITOR'S NOTE ON:

Albert O. Hirschman, Development Projects Observed. © The Brookings Institution, Washington, D. C., 1967. 197 pp.

One might argue that the Principle of the Hiding Hand is altogether too tempting a crutch. It may offer planners, politicians,

aid givers—indeed, all concerned—the convenient notion that investments need not be scrutinized too rigorously, that even white elephants will sooner or later prove worthwhile. Professor Hirschman obviously recognizes this danger, and the remainder of his Development Projects Observed, based on a survey of eleven projects financed by the World Bank, is concerned with elucidating the "interplay between the structural characteristics of projects, on the one hand, and the social and political environment, on the other," in hopes that understanding will prevent "immoderate use" of this crutch.

On the one hand, the effect of environment impinging on a project is to create "uncertainties" and "difficulties," which will differ from project to project but never be absent. On the other, planners are likely to have certain "latitudes" in determining the course of any project. Uncertainties and latitudes are "properties of projects... that condition their total behavior and career."

Sometimes uncertainties can be mitigated. It might be possible, for example, to make a less-than-full commitment to a project while awaiting clarification of environmental factors; thus, it may be a good idea to see which of several new dirt roads gets most traffic before deciding which one to pave. More often, however, "optimal rather than minimal uncertainty or difficulty is the appropriate as well as the only feasible goal." The best that can be hoped for is to trade an unacceptable uncertainty for a more acceptable one. Thus, assurance of adequate financing may reduce assurance that a project organization will feel pressed to maintain a high level of administrative performance; the planner may have to decide how much administrative uncertainty he wishes to trade off for financial certainty. At the very least, he must recognize that a trade-off is involved. Uncertainties of supply and demand, technology, and human factors raise similar problems.

In his influential book, The Strategy of Economic Development, Prof. Hirschman's thesis was that "discipline" should be built into project design, especially with respect to quality, in order to encourage—even force—the growth of attitudes and habits that would make for continuing development. He has now come "a long way from the attractive simplicity" of that concept toward a more "ambivalent" one. In some circumstances, "latitudes" can foster development traits, too. For example, some projects offer useful latitudes in substituting quantity for quality, or private for public outlays—as when private drivers must spend more on car repairs because public roads are deliberately built to lower standards. Such substitutions may, as Prof. Hirschman shows, "result in a roundabout assertion of economic rationality."

Other latitudes relate to time and space. A project may, for example, be "footloose," in that it is not tied to any specific location. Such projects are often smaller, less likely to catch the public imagination, more subject to fragmentation, political favoritism, inadequate funding, poor engineering, and even abandonment. On the other hand, site-bound projects may be too seductive, and end up as white elephants. Recognizing these characteristics latitudes may be half the battle in designing projects to take account of them.

Furthermore, "disciplines" still have their place. Project implementation may be "time-bound"—as a result of seasonal factors, contractual deadlines, pressures from potential customers, and even election dates. Such "disciplines" may be effective in stimulating completion of a project (although there is a danger that speed may be bought at the expense of quality). Possible loss of prestige for the authorities offers another source of discipline. In this connection, Prof. Hirschman suggests that "it may be helpful to increase visibility... through... periodic publication of statistical and other information on the degree of utilization of project capacity."

The social and political environment includes a number of "traits" that may or may not be conducive to development. Many of the so-called side effects of a successful project—e.g., enhanced national self-confidence—are actually critical, if unquantifiable, traits or inputs; without them, the project cannot succeed. One of the planner's jobs is to decide which of these traits can be "made" by designing the project correctly, taking advantage of whatever latitudes and disciplines exist, and which more negative traits must be "taken"—that is, either accommodated to or substituted for (say, by importing the requisite skills). "The risk in trait-making is that the desirable traits which are required for an adequate functioning of the project will simply not be 'made'—that is, learned in time—with dire results for the project's success. If that risk is too big, it is best to revert to some form of trait-taking... or to give up the project altogether." The point is that the essentiality of these traits cannot, as all too often happens, be ignored.

Development Projects Observed is not a "how to do it" book. Rather, it offers an original way of looking at development, as well as innumerable stimulating insights that planners and administrators would do well to ponder.

APPROACHES TO POPULATION CONTROL

A MILESTONE PASSED

Frank W. Notestein

[Intrauterine devices (IUDs) have provided the key to success in family planning in Taiwan and South Korea. Their experience underlines, however, the importance of educating patients and providing follow-up services in order to limit the number of dissatisfied users.]

By the end of 1966, for the first time in history, it could be proved that national family planning programs had brought significant declines in the birth rates of some newly developing countries. The new element in the situation probably is not the fact of the decline, but our ability to document that fact.

The conclusion is not simply reached. One must first establish a number of propositions, often on the basis of inadequate statistical evidence. To arrive at the conclusion we must show: 1) that birth rates declined; 2) that an important element in the decline has been the growth of contraceptive practice; and 3) that the spread of contraceptive practice is, at least in part, the result of the national family planning programs. To these requirements some would add the less reasonable request to prove that birth rates have dropped more rapidly as a result of the national program than they would have dropped if events had taken a different course. One might ask whether birth rates would not have dropped almost as rapidly without a national family planning program because, for example, of a faster rise in the age at marriage, or increased recourse to illegal abortion. In principle, this last request lies outside the possibility of proof. The practical problem is to decide whether the accomplishments are sufficiently promising to justify a

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continuation or intensification of the present approach. From this point of view, the evidence is unambiguous because the accomplishments are real.

South Korea

Let us first take the case of South Korea. Unfortunately, the nation has not maintained accurate statistics of births and deaths. The evidence must be indirect. Special registrations of the population were conducted annually from 1962 through 1965 although they were admittedly incomplete. These show a substantial decline in the ratios between children under age five to women of childbearing age and an especially sharp decline in 1964 and 1965 occurring in every province of the country, rural and urban. Either the birth rate had dropped rapidly throughout the country or other factors give that impression. To cite examples of alternatives, the observed rates would have dropped if infant mortality had risen sharply or larger proportions of children had been omitted on the second than on the first count. It is the impression of those working with the data that neither the health nor the quality of the enumeration has deteriorated. Therefore, it is believed that the decline in the child-woman ratios understates, if anything, the real decline in the birth rate. These ratios would understate the trend in any case because the number of children under age five would nor sharply reflect the maximum impact of the birth control program of the most recent years.

This impression of declining birth rates given by the child-woman ratios is strengthened when we consider the results of repeated sampling surveys relating to knowledge about, attitudes toward, and the practice of contraception (KAP surveys). These surveys are made annually, and show a consistent increase of public knowledge about contraception, of public interest in contraception, and of the proportion of couples practicing contraception. Indeed, the most recent surveys show that about 20 percent of the married women of childbearing age are currently practicing contraception, whereas in 1964 it was only 9 percent.

The service given by the South Korean government's family planning program makes these indications of the child-woman ratios and the KAP surveys wholly credible. Last year, over 390,000 intrauterine devices (IUDs) were inserted, bringing the total in a $2\frac{1}{2}$-year program to 737,000. Since 1962, at least 80,000 male sterilizations have been performed. At the end of 1966 about 170,000 couples were receiving conventional contraceptive supplies from government stations. Altogether, allowing for some duplications, about 900,000 couples have been served by the government program. Since the program began (mostly since 1963), more than 20 percent of the women of childbearing age have received assistance. Moreover, the flow of

patients continues in 1967 with no indication that a saturation point has been reached.

It is possible, indeed probable, that contraception is to some extent serving as a substitute for abortion, so that births prevented by contraception do not represent net reductions. It is not possible to suppose, however, that the contraceptive program has not brought a substantial decline in birth rates. On admittedly weak evidence, Korea's Planning Board calculated that the rate of natural increase estimated at 3 percent in 1962 had dropped to about 2.5 percent by 1966. The Board has set as a target a further reduction to 2 percent by 1971. On any reading the record has been quite remarkable.

Taiwan

In the case of Taiwan, which has good statistics, there is no question about the decline of the birth rate. It was 45 per 1,000 in 1955, and by 1964 had been reduced to 34.5. It fell to 32.7 in 1965 and to 32.4 in 1966. The figure for 1966, moreover, was artificially inflated by the fact that a census in December brought in early registrations of births that would normally have come in the following year, as well as a number of birth registrations omitted for previous years. Without these exceptional circumstances, the figure for 1966 probably would have been about 31. The target is to reach a birth rate of 20 by 1973.

In Taiwan there is no question that a decline in the birth rate took place. The only question is about the extent to which that decline can be attributed to the family planning program. The rate was declining before the program got under way, thanks apparently to a rising age at marriage, to an increased practice of contraception, and also probably to some increase in illegal abortion. Since the program began, however, the rate of decline has accelerated and, moreover, within the island the reduction of the birth rate has been positively correlated with the depth of the family planning service. As is to be expected, much the sharpest decline in fertility has come among older women. It is, therefore, particularly interesting to note that the fertility rate for women aged 25-29 began to fall between 1964 and 1965. Moreover, the proportion of patients receiving help who had only three children has definitely increased.

As in Korea, the service statistics from the Taiwan family planning program suggest the importance of the work. The program has depended very heavily on the Lippes loop, for which the target has been 600,000 insertions in five years. At the half-way point the actual number of insertions falls only 39,000 short of 300,000 and this figure would clearly have been higher if the staff of field workers had been brought up to quota. It is difficult to say what the exact impact

has been on the birth rate. Mauldin, in "Retention of IUDs: An International Comparison" [Studies in Family Planning, The Population Council, April 1967], has shown that simply maintaining the present number of IUDs in situ would prevent enough births to reduce the crude birth rate by 3 to 5 per 1,000 population per year. (The corresponding figure for South Korea is between 3.7 and 5.3.) On the one hand, this overstates program effects by disregarding the fact that many women using the IUD might, in the absence of the program, have turned to something else. On the other hand, it understates the effects because it ignores the women using methods other than the IUD as a result of the program.

In "Taiwan: Births Averted by the IUD Program," [Studies in Family Planning, June 1967], Chow and Freedman have shown that most of the women who discontinued did not return to unprotected status. Some were sterilized; some resorted to abortion; others turned to conventional methods of contraception. Indeed, based on a careful sample study of initial IUD acceptors, Chow and Freedman estimated that the fertility of the group as a whole, including those who have discontinued use, is reduced by between half and two-thirds of the expected level. In short, women coming for family planning services cut their fertility sharply, and by the end of 1966 more than 20 percent of the women of childbearing age in Taiwan had received assistance. Although the precise impact of the family planning program on the birth rate cannot be closely calibrated, there can be no doubt that it resulted in stimulating contraceptive practice sufficiently to reduce the birth rate substantially. There is no obvious reason to suppose that in the absence of such a program birth rates would have declined nearly as much.

With mounting interest on the part of younger women, the experimental introduction of the oral pill, and an intensification of field work, there is every reason to expect a further reduction in fertility. In the next years it may be difficult to attain a rapid reduction in the crude birth rate because the children of the postwar baby boom will be entering the childbearing period to swell the numbers of potential mothers. Much must still be done if a birth rate of 20 is to be achieved by 1973, but recent experience and a progressively strengthened program suggest that the goal is realistic.

One can also show that strong family planning programs in Hong Kong and Singapore have been important factors in reducing crude birth rates there.

India and Pakistan

Much less can be claimed for the effect of family planning programs on the crude birth rates of India and Pakistan. Their

comparative lack of success is often cited to suggest that such programs can only succeed where the underlying socioeconomic situation is favorable. It has been argued, for example, that family planning programs are succeeding in Taiwan, Hong Kong, and Singapore because these are highly secular societies with rising prosperity and literacy and with sharply visible limits to their possibilities for expansion; or that in South Korea, family planning is taking hold because recent political events have broken the cake of custom in that somewhat secular population. That these attributes provide a favorable setting for family planning cannot be denied. It is still much too early, however, to assume that family planning programs are ineffective in other settings.

India and Pakistan have had formal programs since 1955 and 1961 respectively, but in fact these programs have assumed substance only recently. Indeed, it was not until the new intrauterine device became available that many leaders in these nations became convinced that they had a method of sufficient promise to warrant the establishment of a major family planning service. Now the programs are beginning to move. The data on India are not very good but it is clear that by the end of 1966 something like 1.25 million IUDs had been inserted. Some 500,000 Pakistanis had received IUDs and, at the time of writing, summer of 1967, more than 50,000 IUDs were being inserted each month. Mauldin estimates that the number of IUDs in situ in Pakistan by the end of 1966 would, if maintained, be sufficient to cut a little more than one point off the birth rate. At the same time, both countries were going ahead with sterilization, with the use of conventional contraceptives, and, more recently, with experimental work on the oral steroids. At long last, the programs of these huge countries were beginning to get organized so that prospects for success were much improved.

Lessons from Experience

Throughout the newly developing nations as a whole birth rates have not been reduced by family planning programs, but a few initial successes show that they can be reduced and recent experience with the revitalized programs in such large countries as India and Pakistan suggest that successes may soon be attained even in the difficult cases.

It is often argued that in the traditional societies people are not really ready for or interested in family planning. The experience of the Population Council is that the people are amazingly ready and that the difficulty lies in the failure of governmental personnel to realize that fact. Naturally the people of traditional societies are not usually interested in limiting their families to two or three children. Their first interest comes in wanting to have no more than four or five. But, as survey after survey in country after country has shown, a

substantial majority of couples want to limit the number of their children and experience with many pilot projects has demonstrated that they will come for help to any well-organized family planning service even in the face of surprisingly adverse situations. There is no dearth of patients whenever a reasonable service of information, supplies, and medical assistance is available.

The first family planning successes in the newly developing world are a testimonial to the IUD. It is, therefore, both curious and important to note that the year in which the first claims of successful reductions in birth rates could be made, thanks to the effectiveness of the IUD, was also the year in which some disillusionment with the IUD began to emerge. It now appears that something like 50 percent, or with re-insertions 60 to 65 percent, of the initial acceptors will continue to wear the IUD after two years. Those who discontinue include women who have come to menopause, women whose marriages are broken, and those who want another child. But they also include some 20 to 30 percent of acceptors who could not retain or tolerate the IUD. Pregnancy rates among users are relatively low, running to some two to three per 100 women a year, including those that occur as a result of unnoticed expulsions. This rate is less than half that to be expected in the best experience with conventional contraceptives and it is of the same order as the pregnancy rate accompanying the widespread use of oral steroids. The upshot is that, at least for the first two years, the IUD gives excellent protection to some 50 to 60 percent of the women who accept it, with something like 20 to 30 percent discontinuing for reasons that reflect on the usefulness of the method in field programs.

The experience with the IUD contains much instructive material. At first, too much attention was paid to the method as a kind of ideal exercise and too little attention to its use in actual practice. In the first flush of enthusiasm about a method that was both new and loaded with promise, too much attention was given to speeding the work and too little attention paid to informing women about difficulties they might expect in the first two months of wearing an IUD. When uninformed women encountered minor difficulties, they tended to discontinue. Experience has by now underlined for us the importance of informed and conscientious service. Some physicians have had rates of discontinuation as low as 15 percent, whereas others have had rates more than four times that high. Moreover, where initial service has been inadequate, dissatisfied women have spread adverse gossip and encouraged others to discontinue. Every program must count on favorable word-of-mouth communication. Satisfied women bring in their friends, but dissatisfied women can also win converts to their side.

In short, important as it is to have a satisfactory method, it is equally important that women be given a real understanding of what they can expect. Many of us at work on population problems have tended to stress medical techniques and to underestimate problems of patient education. Given proper attention and an eye to the quality of service, the IUD has a central and continuing role to play in family planning programs. It is not—nor was it ever expected to be—the perfect contraceptive that would displace all others. Yet for all the problems that have revealed themselves in large-scale use, the IUD has already turned in a remarkable performance. Its shortcomings loom large only in relation to a hypothetical ideal.

This disposition to have faith in a method apart from the quality of service which accompanies it—combined with our lack of knowledge about the effectiveness of the oral steroids in practice—seems to be generating some dubious advice. There has been some tendency to conclude that oral steroids ought to be substituted for the IUD now that the cost of pills has dropped to manageable levels. Pills are known to be safe, inexpensive, and, for those who continue to use them in accordance with instructions, effective. The difficulty is that in the absence of practical field experience it is assumed that the effectiveness obtained in ideal use will carry over to their use in field programs. Although a few small and carefully supervised studies have given favorable results, the preliminary experience in both South Korea and Taiwan shows that the proportions discontinuing the use of the oral steroids runs very much higher than do those with the IUD. Here too, however, the continuation rates will undoubtedly depend on the quality of the service.

Since a considerable proportion of patients cannot tolerate each new method, we are fortunate indeed to be able to backstop one method with the other. Each of them represents a major breakthrough in contraceptive technology. Each deserves to have its usefulness unimpaired by our ignorance and our administrative failures. The difficulties now being encountered are minimal compared with the main fact that national family planning programs now have two cheap and highly effective methods which separate contraception from the act of coition and which are already helping to reduce the birth rates of several newly developing countries.

The first initial successes must be welcomed as showing that concerted action can bring solutions. They do not show that the problems have been solved. Indeed, the essential work has scarcely begun. Any real resolution of the crisis of growth will require the best efforts of the governments concerned, of international agencies, and of the governmental and private agencies of the developed world.

[Excerpted from "Report of the President," Annual Report, 1966. New York: The Population Council, 1967, pp. 11-21.]

WILL FAMILY PLANNING PROGRAMS SUCCEED?

Kingsley Davis

[Family planning programs may produce a decline in birth rates, but they cannot achieve population control. Any serious program to limit population size must place primary emphasis on manipulating the social and economic determinants of reproductive behavior.]

Most observers are surprised by the swiftness with which concern over the population problem has turned from intellectual analysis and debate to policy and action. More than thirty nations are now trying or planning to reduce population growth and numerous private and international organizations are helping. But relief that "at last something is being done" is no guarantee that what is being done is adequate.

The degree of unanimity as to the kind of measures needed is impressive and can be summed up in the phrase "family planning"—a euphemism for contraception. The family-planning approach to population limitation concentrates on providing new and efficient contraceptives on a national basis through mass programs under public health auspices. What is wrong with such programs? Nothing at all, if they work. Whether or not they work depends on what they are expected to do as well as on how they try to do it. Let us discuss the goals first, then the means.

Goals

Curiously, it is hard to find in the population-policy movement any explicit discussion of long-range

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policy goals. Technically, the terms population control and population planning would mean deliberate influence over all attributes of population, including its age-sex structure, geographical distribution, racial composition, genetic quality, and total size. No government attempts such full control. Rather, current population policies are concerned only with the growth and size of populations. Even these attributes, however, result from the death rate and migration as well as from the birth rate; their control would require deliberate influence over the factors giving rise to all three determinants. But in actuality, current policies labeled population control or fertility control deal only with the birth input, and even then do not undertake to influence most of the determinants of human reproduction.

Current programs seem to be aiming simply to achieve a reduction in the birth rate. In the rare cases where a specific demographic aim is stated, the goal is said to be a short-run decline within a given period. For example, the Pakistan plan, adopted in 1966, aims to reduce the birth rate from 50 to 40 per 1,000 by 1970; the Indians plan to reduce it from 40 to 25 "as soon as possible"; the Korean aim is to cut population growth from 2.9 to 1.2 percent by 1980. A significant feature of such goals is the rapid population growth they would permit. Under conditions of modern mortality, a crude birth rate of 25 to 30 per 1,000 will represent such a multiplication of people as to make the term population control ironic. A rate of increase of 1.2 percent per year would allow South Korea's already dense population to double in less than 60 years.

One can, of course, defend the programs by saying that the present goals and measures are merely interim ones. A start must be made somewhere. But such a defense, if convincing, would require a presentation of the next steps, and these are not considered. A consideration of hypothetical goals throws further light on the matter.

Industrialized nations as the model. Industrial nations, long oriented toward family planning, provide a good yardstick for determining what the availability of contraceptives can do to population growth. Indeed, they are actually the model which inspired the present population policies.

What does this goal mean in practice? The birth rates of most industrial nations have shown, since about 1940, a wave-like movement, with no secular trend. The average level of reproduction during this period has been high enough to give these countries, with their low mortality, an extremely rapid population growth. If this level is maintained, their population will double in just over 50 years—a rate higher than that of world population growth at any time prior to 1950.

Zero population growth as a goal. Most discussions of the population crisis lead logically to zero population growth as the ultimate goal, because any growth rate, if continued, will eventually use up the earth. Yet hardly ever do arguments for population policy consider such a goal, and current policies do not dream of it. Why not? Evidently zero population growth is unacceptable to most nations and to most religious and ethnic communities. To argue for this goal would be to alienate possible support for action programs.

Goal peculiarities inherent in family planning. The very use of family planning as the means for implementing population policy poses serious, but unacknowledged, limits on the intended reduction in fertility. "The opportunity to decide the number and spacing of children is a basic human right" say twelve heads of state in their United Nations declaration of 10 December 1966. But logically, it does not make sense to use family planning to provide national population control or planning. The "planning" in family planning is that of each separate couple. The only control they exercise is over the size of their family. There is no reason to expect that the millions of decisions about family size made by couples in their own interest will automatically control population for the benefit of society. On the contrary, there are good reasons to think they will not do so.

Actually, the family planning movement does not pursue even the limited goal it professes. It does not fully empower couples to have only the number of offspring they want because it either condemns or disregards certain tabooed, but effective, means to this goal. Induced abortion, for example, is one of the surest means of controlling reproduction, and one that has been proved capable of reducing birth rates rapidly. It seems peculiarly suited to the threshold stage of a population-control program—the stage when new conditions of life first make large families disadvantageous. It was the principal factor in halving the Japanese birth rate, a major factor in the declines in birth rate of East European countries in the early 1950s, and an important factor in the reduction of fertility in industrialized nations from 1870 to the 1930s. Today, according to the Population Council's Studies in Family Planning, illegal "abortion is probably the foremost method of birth control throughout Latin America." Yet this method is rejected in nearly all national and international programs. Family planning is presented as a means of combating abortion.

Although few would prefer abortion to efficient contraception, the fact is that both permit a woman to control the size of her family. The main drawbacks to abortion arise from its illegality. When performed as a legal procedure by a skilled physician, it is safer than childbirth. It does not compete with contraception but serves as a backstop when the latter fails or when contraceptive devices or information are not available. As contraception becomes customary, the incidence of abortion recedes even without its being banned.

The questions of sterilization and unnatural forms of sexual intercourse usually meet with similar silent treatment or disapproval, although nobody doubts the effectiveness of these measures in avoiding conception. Moreover, not every individual may choose; even the so-called recommended methods are ordinarily not offered to single women, or not all offered to women professing a given religious faith. Despite reference to "population control" and "fertility control," which presumably means determination of demographic results by and for the nation as a whole, the family-planning movement gives control only to couples, and does this only if they use "respectable" contraception.

The Example of Taiwan

Some observers have carelessly attributed the decline in Taiwan's birth rate—from 50.0 in 1951 to 32.7 in 1965—to its highly organized family planning program. But the campaign began only in 1963 and could have affected only the end of the trend. At most, it could have caused the increase observable after 1963 in the rate of decline. Between 1951 and 1963 the average drop in the birth rate per 1,000 women was 1.73 percent per year; in 1964-66 it was 4.35 percent.

But one hesitates to assign all of this acceleration in decline to the family planning campaign. The rise in manufacturing has been much greater than the rise in either agriculture or construction. The agricultural labor force has thus been squeezed, and migration to the cities has skyrocketed. Since housing has not kept pace, urban families have had to restrict reproduction in order to take advantage of career opportunities and avoid domestic inconvenience. Such conditions have historically tended to accelerate a decline in birth rates. The main evidence that some of this acceleration is due to the campaign comes from the fact that Taichung, the city in which the family planning effort was first concentrated, showed subsequently a much faster drop in fertility than other cities. But most of the reduction in fertility has been a matter of individual initiative. To some extent the campaign may be simply substituting sponsored (and cheaper) services for those that would otherwise have come through private and commercial channels.

The important question, however, is whether even a successful family planning campaign will provide population control for the nation. What is the maximum impact possible? It is the difference between the number of children women have been having and the number they want to have. In a sample of wives aged 25 to 29 in Taichung, a city of over 300,000, researchers found the average number of children wanted was 4; only 9 percent wanted fewer than 3; 20 percent wanted 5 or more. If, therefore, Taiwanese women used contraceptives that were 100 percent effective, and had the number of children

they desire, they would have about 4.5 each. In the past, the Taiwanese woman who married and lived through the reproductive period had, on the average, about 6.5 children; thus, a figure of 4.5 would represent a substantial decline in fertility. The population growth rate would decline somewhat less, however, since mortality would continue to decline. With 4.5 births per woman and a life expectancy of 70 years, the rate of natural increase would still be close to 3 percent per year.

In the future, Taiwanese views concerning reproduction will doubtless change. Detailed data confirm the interpretation that Taiwanese women are shifting from a "peasant-agrarian" to an "industrial" level of reproduction. They are, in typical fashion, cutting off higher-order births at age 30 and beyond. But what result can be hoped for? In the United States in 1966, an average of 3.4 children was considered ideal by white women aged 21 and over. This average number of births would give Taiwan, with only a slight decrease in mortality, a long-run rate of natural increase of 1.7 percent per year and a doubling of population in 41 years.

In areas less developed than Taiwan or South Korea, where some "success" has been claimed, the degree of acceptance of contraception tends to be disappointing, especially among the rural majority. In the rural Punjab, for example, among 5,196 women coming to family planning centers, 38 percent were over 35 years old, 67 percent over 30. These women had married early, nearly a third of them before the age of 15; some 14 percent had eight or more living children when they reached the clinic, 51 percent six or more. A survey in Tunisia showed that 68 percent of the married couples were willing to use birth-control measures, but the average number of children they considered ideal was 4.3. The corresponding averages for a village in eastern Java, a village near New Delhi, and a village in Mysore were 4.3, 4.0, and 4.2 respectively.

In the cities of these regions women are more ready to accept birth control and they want fewer children than village women do, but the number they consider desirable is still wholly unsatisfactory from the standpoint of population control. In an urban family planning center in Tunisia, more than 600 of 900 women accepting contraceptives had four living children already. In Bangalore, a city of nearly a million at the time (1952), the number of offspring desired by married women was 3.7 on the average; by married men, 4.1. In the metropolitan area of San Salvador, a 1964 survey showed the number desired by women of reproductive age to be 3.9, and in seven other capital cities of Latin America the number ranged from 2.7 to 4.2. If women in the cities of underdeveloped countries used birth-control measures with 100 percent efficiency, they would still have enough babies to expand city populations senselessly, quite apart from the added contribution of rural-urban migration.

The Neglect of Motivation

The problem woman from the standpoint of family planners is the one who wants "as many children as come," or "as many as God sends." Her attitude is construed as due to ignorance and "cultural values," and the policy deemed necessary to change it is "education." Movie strips, posters, comic books, public lectures, interviews, and discussions are in order. These supposedly discount superstitions and show that unrestrained procreation is harmful to both mother and children. The effort is considered successful when the woman decides she wants only a certain number of children and uses an effective contraceptive. But suppose a woman does not want to use any contraceptive until after she has had four children. This is the type of question that is seldom raised in the family-planning literature.

Designation of population control as a medical or public health task assures popular support because it puts population policy in the hands of respected medical personnel, but, by the same token, it gives responsibility for leadership to people who think in terms of clinics and patients, of pills and IUDs. Overpopulation becomes a disease, to be treated by a pill or a coil. But concentration on birth-control technology represents an escape from the necessity, and onus, of grappling with the social and economic determinants of reproductive behavior. Changes basic enough to affect motivation for having children would be changes in the structure of the family, in the position of women, and in sexual mores. Far from proposing such radicalism, spokesmen for family planning frequently state their purpose as "protection" of the family—that is, closer observance of family norms. We thus see that the inadequacy of current population policies with respect to motivation is inherent in their overwhelmingly family-planning character.

This conclusion is confirmed by demographic facts. In backward countries today, taken as a whole, birth rates are rising, not falling. In one study made by our office, in which estimating methods derived from the theory of quasi-stable populations were used, the trend was found to be upward in 27 underdeveloped countries, downward in six, and unchanged in one. Some of the rises have been substantial, and most have occurred where the birth rate was already extremely high. For instance, the gross reproduction rate rose in Jamaica from 1.8 per 1,000 in 1947 to 2.7 in 1960; among the natives of Fiji, from 2.0 in 1951 to 2.4 in 1964. This general rise in fertility is due, ironically, to the very circumstances that brought on the population crisis in the first place—improved health and lowered mortality. Better health increases the probability that a woman will conceive and retain the fetus to term; lowered mortality raises the proportion of babies who survive to the age of reproduction and reduces the

probability of widowhood during that age. Some of the upward pressure on birth rates is thus independent of what couples do about family planning, for it arises from the fact that, with lowered mortality, there are simply more couples.

If this characterization is accurate, we can conclude that current programs will not enable a government to control population size. At most, family planning can reduce reproduction to the extent that unwanted births exceed wanted births. In countries where couples have numerous offspring that they do not want, such programs may possibly accelerate a birth rate decline that would occur anyway. But the elimination of unwanted births would still leave an extremely high rate of multiplication. The conditions that cause births to be wanted or unwanted are beyond the control of family planning, hence beyond the control of any nation which relies on family planning alone as its population policy.

New Directions in Population Policy

To continue to offer a remedy as a cure long after it has been shown merely to ameliorate the disease is either quackery or wishful thinking, and it thrives most where the need is greatest. Today the desire to solve the population problem is so intense that we are all ready to embrace any "action" program that promises relief. But postponement of effective measures allows the situation to worsen.

In thinking about other approaches, one can start with known facts. In the past, all surviving societies had institutional incentives for marriage, procreation, and child care which were powerful enough to keep the birth rate equal to or in excess of a high death rate. Despite the drop in death rates during the past century and a half, the incentives tended to remain intact because the social structure (especially in regard to the family) changed little.

If excessive population growth is to be prevented, the obvious requirement is somehow to impose restraints on the family. What is required is not "abolition" of the family but, rather, a selective restructuring of it in relation to the rest of society. The lines of such restructuring are suggested by two existing limitations on fertility: First, nearly all societies succeed in drastically discouraging reproduction among unmarried women. Second, advanced societies unintentionally reduce reproduction among married women when conditions worsen in such a way as to penalize childbearing more severely than it was penalized before. In both cases, the causes are motivational and economic rather than technological. It follows that population control policy can de-emphasize the family in two ways: 1) by keeping present controls over illegitimate childbirth yet making the most of factors that lead people to postpone or avoid marriage, and 2) by

instituting conditions that motivate those who do marry to keep their families small.

Postponement of marriage. Since the female reproductive span is short and generally more fecund in its first than in its second half, postponement of marraige to ages beyond 20 tends biologically to reduce births. Sociologically, it gives women time to get a better education, acquire interests unrelated to the family, and develop a cautious attitude toward pregnancy. Individuals who have not married by the time they are in their late twenties often do not marry at all. For these reasons, for the world as a whole, the average age at marriage for women is negatively associated with the birth rate.

Any suggestion that age at marriage be raised as a part of population policy is usually met with the argument that "even if a law were passed, it would not be obeyed." But other factors actually govern the age at marriage. In agrarian societies, when postponement of marriage occurs, it is apparently caused by difficulties in meeting the economic prerequisites for matrimony, as stipulated by custom and opinion. In industrial societies it is caused by housing shortages, unemployment, the requirement for overseas military service, high costs of education, and inadequacy of consumer services. Since almost no research has been devoted to the subject, it is difficult to assess the relative weight of these and other factors.

Encouraging limitation of births within marriage. As a means of encouraging the limitation of reproduction within marriage as well as postponement of marriage, a greater rewarding of non-familial than of familial roles would probably help. A simple way of accomplishing this would be to allow economic advantage to accrue to the single as opposed to the married individual, and to the small as opposed to the large family. For instance, the government could pay people to permit themselves to be sterilized; all costs of abortion could be paid by the government; a substantial fee could be charged for a marriage license; a "child-tax" could be levied; and there could be a requirement that illegitimate pregnancies be aborted.

Less sensationally, governments could simply reverse some existing policies that encourage childbearing. They could, for example, cease taxing single persons more than married ones, stop giving parents special tax exemptions; abandon income-tax policy that discriminates against couples when the wife works; reduce paid maternity leaves; reduce family allowances; stop awarding public housing on the basis of family size; stop granting fellowships and other educational aids (including special allowances for wives and children) to married students; cease outlawing abortions and sterilizations; and relax rules that allow use of harmless contraceptives only with medical permission. Some of these policy reversals would be beneficial

in other than demographic respects and some would be harmful unless special precautions were taken. The aim would be to reduce the number, not the quality, of the next generation.

A closely related method of de-emphasizing the family would be modification of the complementarity of the roles of men and women. Men are now able to participate in the wider world yet enjoy the satisfaction of having several children because the housework and child care fall mainly on their wives. Women are impelled to seek this role by their idealized view of marriage and motherhood and by either the scarcity of alternative roles or the difficulty of combining them with family roles. To change this situation women could be required to work outside the home, or compelled by circumstances to do so. If at the same time women were paid as well as men and given equal educational and occupational opportunities, and if social life were organized around the place of work rather than around the home or neighborhood, many women would develop interests that would compete with family interests. Approximately this policy is now followed in several Communist countries, and even the less developed of these currently have extremely low birth rates. But in most countries, the wife's employment is subordinate, economically and emotionally, to her family role, and is readily sacrificed for the latter. No society has restructured both the occupational system and the domestic establishment to the point of permanently modifying the old division of labor by sex.

In any deliberate effort to control the birth rate along these lines, a government has two powerful instruments—its command over economic planning and its authority (real or potential) over education. The economic system largely determines who shall work, what can be bought, what rearing children will cost, how much individuals can spend. The schools define family roles and develop vocational and recreational interests; they could, if it were desired, redefine the sex roles, develop interests that transcend the home, and transmit realistic (as opposed to moralistic) knowledge concerning marriage, sexual behavior, and population problems. When the problem is viewed in this light, it is clear that the ministries of economics and education, not the ministry of health, should be the source of population policy.

The Dilemma of Population Policy

In sum, the things that make family planning acceptable are the very things that make it ineffective for population control. By stressing the right of parents to have the number of children they want, it evades the basic question of population policy, which is how to give societies the number of children they need. By offering only the means for couples to control fertility, it neglects the means for societies to do so.

Because of the predominantly pro-family character of existing societies, individual interest ordinarily leads to the production of enough offspring to constitute rapid population growth under conditions of low mortality. Childless or single-child homes are considered indicative of personal failure, whereas having three to five living children gives a family a sense of continuity and substantiality. Thus, the only countries in which fertility has been reduced to match reduction in mortality are advanced ones temporarily experiencing worsened economic conditions. When conditions are good, any nation tends to have a growing population.

No government will institute economic hardships simply for the purpose of controlling population growth. Clearly therefore, the task of contemporary population policy is to develop attractive substitutes for family interests. The unthinking identification of family planning with population controls is an ostrich-like approach in that it permits people to hide from themselves the enormity and unconventionality of the task.

To acknowledge that family planning does not achieve population control is not to impugn its value for other purposes. Freeing women from the need to have more children than they want is of great benefit to them and their children and to society at large. My argument is therefore directed not against family planning programs as such, but against the assumption that they are an effective means of controlling population growth. There is no reason to abandon family planning programs; contraception is a valuable technological instrument. But such programs must be supplemented with equal or greater investments in research and experimentation to determine the required socioeconomic measures.

[Condensed from "Population Policy: Will Current Programs Succeed?," Science. Washington (D. C.): American Association for the Advancement of Science, Vol. 158, No. 3802, 10 November 1967, pp. 730-739.]

THE MALTHUSIAN SQUEEZE AND THAILAND

Edward Van Roy

[Current production and population trends mean that Thailand's position as a rice exporter is doomed to end in the 1970s. The resulting crisis will only be remedied if countermeasures are started immediately to raise rice yields, reduce domestic demand, and diversify the economy.]

Since its entry into the international economic arena more than a century ago, Thailand has relied heavily on its rice surplus to pay for its imports, to maintain its financial system in sound order, and more recently to subsidize the growth of its non-agricultural economy and urban population. Due to its good fortune in having consistently had abundant harvests, the country has managed to pursue these three aims with substantially less difficulty than most of her Asian neighbors. It would be difficult to conceive of Thailand's foreign trade position (and, consequently, of her ability to continue to import needed capital goods, attract foreign investment, and implement a sound economic and social development effort) in the absence of the rice-surplus component. And yet, this situation, disastrous as it seems, is the one toward which the country is irresistibly drifting.

Surely, Malthus had present-day Thailand in mind when he published his "Essay on Population" in 1798. The current tendency of Thailand's population to grow more rapidly than the country's rice output seems a classic example of his famous principle. The net result of this tendency, in the face of a steady per capita demand for rice domestically, will be a secular decline

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in rice exports. This essentially simple relationship, shown in the accompanying chart, is of sufficient importance that it should be spelled out here in some detail.

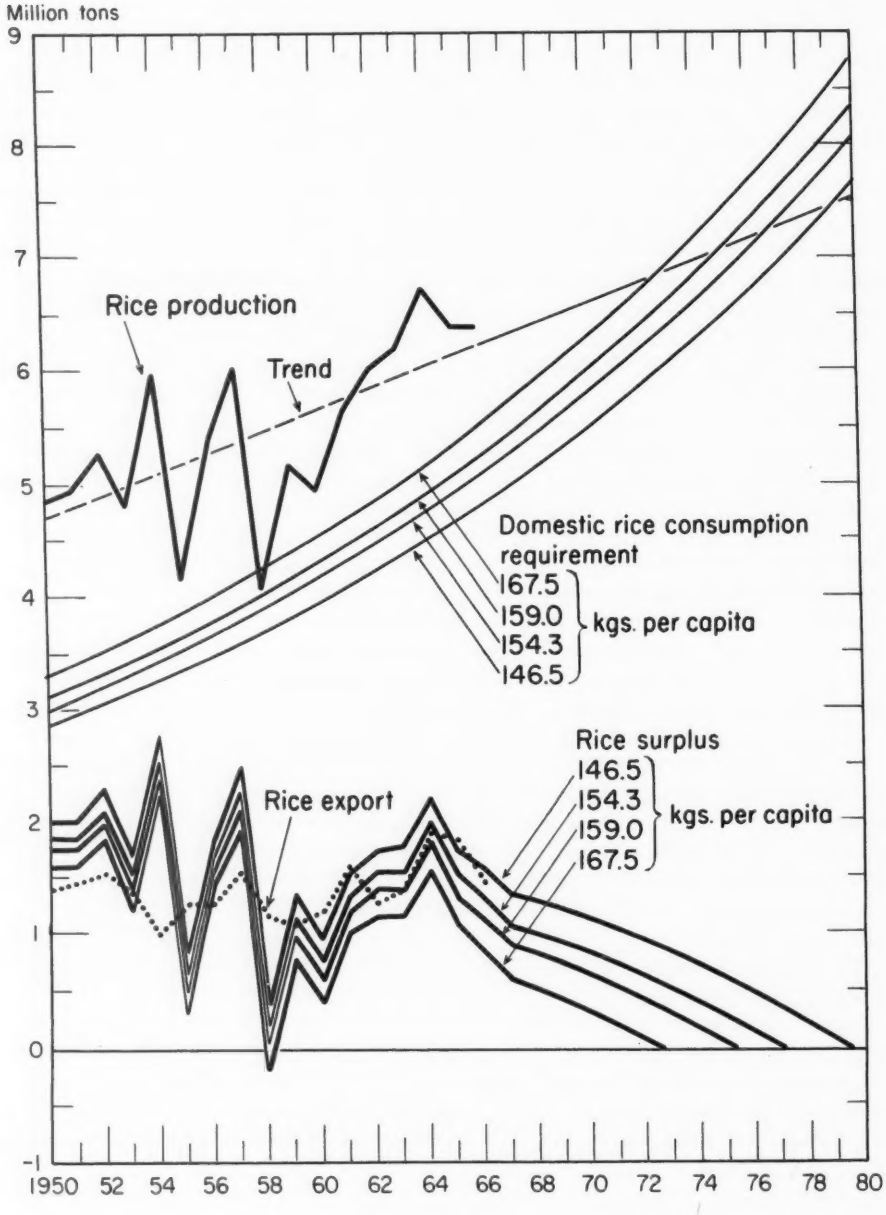
On the basis of Ministry of Agriculture data, revised for understatements uncovered by the 1963 Census of Agriculture surveys, a linear trend can be constructed showing that, on the basis of 1949/50-1965/66 experience, paddy production can be expected to increase by an average of 153,000 metric tons annually on a computed 1949/50 base of 7.5 million tons. According to this trend, production will reach 10.6 million tons in 1969/70 and 12.1 million tons in 1979/80.

A time series for rice production can be derived by deducting from paddy output the volume of paddy used up for each following crop's seed, for animal feed, and for storage and milling loss. A conservative figure of 5.0 percent will be used here. Milling loss or "conversion factor," additionally, is conventionally computed at 34 percent of the remaining paddy supply. The total conversion rate from paddy to rice is thus 62.7 percent. On this basis, rice available for domestic consumption and for export amounted to 4.9 million tons in 1949/50 and 6.4 million tons in 1965/66. By extrapolation, 6.7 million tons will be available in 1969/70 and 7.5 million tons in 1979/80. Rice production is thus expected to grow by an average of 96,000 tons per annum.

From the rice production figures thus derived, the volume of rice available for domestic consumption can be computed for each past year by deducting rice exports. (Crop years have been converted to the calendar years of final harvests.) Because a substantial proportion of rice consumed in each year is "old rice" (i.e., rice held over from the previous harvest), a two-year moving average of rice available for domestic consumption has been used. These data, divided by mid-year population, result in an average annual per capita rice consumption figure of 159.0 kgs. [1 kilo = 2.2 lbs.] Other recent studies have come to similar conclusions, with estimates of 167.5 kgs. (National Statistical Office), 154.3 kgs. (NEDB), and 146.5 kgs. (ECAFE). These averages have been used as "indexes" for projections on the chart—overleaf.

An analysis of the National Economic Development Board population estimates from 1947 to 1970 indicates that the rate of growth rose from 2.9 percent in the first year to 3.4 percent in 1956 and that it is expected to decline to 3.3 percent in 1967. The figures have here been projected beyond 1970 at a constant growth rate of 3.3 percent. On this basis, the mid-1966 population of 33 million will expand to over 52 million by mid-1980.

Rice Production, Consumption and Exportable Surplus Thailand, 1950-1980



Sources: Data from Ministry of Agriculture, NEDB, and the Bank of Thailand, revised and projected.

Domestic rice consumption requirements for future years can now be estimated by multiplying the per capita rice consumption requirement by mid-year population estimates. According to the various assumed per capita intake levels of 167.5 kgs., 159.0 kgs., 154.3 kgs., and 146.5 kgs., aggregate domestic demand for rice in 1975, for instance, will be 7.4 million tons, 7.1 million tons, 6.8 million tons, and 6.5 million tons, respectively.

The Malthusian squeeze can now be pinpointed. With a per capita annual requirement of 167.5 kgs., the aggregate rice requirement will outrun rice production in 1973; with a per capita requirement of 159.0 kgs., demand will overtake supply in 1976; at 154.3 kgs., the shortfall will occur in 1977; and at 146.5 kgs., it will occur in 1980.

These predictions leave us with a significant conclusion. Despite a fairly wide range of alternative per capita rice consumption requirements, the trend of domestic rice consumption will bypass that of production sometime between 1973 and 1980. The date of Thailand's metamorphosis from a rice surplus to a rice deficit country thus looms on the horizon, no more than 13 years away and possibly sooner.

Having traced his way through this jungle of assumptions and not-entirely-reliable data, the reader may possibly reflect as follows: "Yes—but those rice export data; there's no declining trend evident there. In fact, 1964 and 1965 were the largest export years (by volume) on record! So, where's the squeeze?"

A large part of the answer is implicit in the international politics which suffuse a large share of the rice export trade. Between mid-1959 and mid-1965, for instance, some 36 percent of the volume of rice exported from Thailand was on a government-to-government basis, i.e., negotiated through diplomatic channels. Much of this public sector rice trade has been on a long-term contract and credit basis, meaning that any momentary deficiency in rice export supplies has to be drawn from domestic reserves.

The remaining part of the answer is implicit in the internal political role played by Thailand's rice trade. Rice exports are heavily taxed, about 35 percent of their f.o.b. value flowing to the government. These export duties, particularly the rice "premium," account for roughly 10 percent of total government revenues; and they are among the least costly and administratively cumbersome revenues collected. A decline in rice exports would thus have a serious impact on Thailand's fiscal situation. Though total receipts from the premium could be maintained with a fall in rice exports if the tax rate were raised, this course would dangerously magnify the already large indirect tax burden on the rice farmer.

If this rationale concerning the government's reluctance to decrease rice exports despite the pressures of reduced surplus is correct, the domestic crisis which is here anticipated to occur between 1973 and 1980, with the absolute disappearance of the rice surplus, will actually occur even sooner. In fact, deducting the average annual export volume for the 1950/65 period from the projected surplus data, the crisis should occur during 1967 or 1968, when the total volume of rice production will no longer be sufficient to satisfy both export and domestic requirements.

Thus, on the basis of post-war tendencies, the immediate prognosis for Thailand's rice industry, and consequently for her economy as a whole, is not bright. Within the coming decade the country is predicted to lose entirely her already declining rice surplus, which means that she will be placed in serious balance-of-payments difficulties and will lose a major source of public revenues. Inflationary pressures will be generated as less than adequate domestic rice supplies are distributed among a growing population, resulting in increasing hardship for the great poverty-level majority of the people, particularly those in the urban-industrial sector. The constraints placed on public development expenditures due to diminishing public revenues and increasing social welfare and civil-servant wage expenditures (necessitated by the declining sectoral terms of trade of industrial labor and the salaried cadres) may carry adverse linkage effects to foreign investment in Thailand, which will at any rate be repelled by the non-boom inflation.

The picture sketched here is one of fiscal crisis and economic recession resulting from structural transformation in Thailand's balance of trade, compounded by an emerging domestic deficit in rice. Considering the facts that today the average Thai family spends one-fifth of its total outlay on rice, that the rice industry accounts for roughly one-fourth of the national income, that the share of rice in exports is over one-third, and that the government depends on rice exports for one-tenth of its revenues, the dim future predicted here may not be as exaggerated a representation of coming events as may be assumed by the conservatively inclined reader.

Potential Countermeasures

The chain of events leading to economic downturn can be dealt with if foreseen and properly countered. The most important measure, and the one to which the government seems to be turning (though for other reasons), is to increase the rate of growth of rice production.

Produce more rice. Improving the annual yield on land previously planted to paddy can be accomplished by a variety of techniques, the most common being: constructing irrigation projects to systematize

flooding and to open possibilities of double, or even triple, cropping; producing (or importing) and distributing fertilizers, and teaching farmers their proper use; introducing new varieties of seed; establishing agricultural extension services; making mechanized equipment available; and controlling marketing channels to assure farmers of the highest possible return per unit and to assure them of stable rice prices.

Opening new territories to rice cultivation may also be practicable. Irrigation projects nearly invariably have this as one of their purposes. Fertilizers, new varieties of rice seed, and new production techniques may also prove successful in opening marginal land to rice. The Thai government's land settlement program has made some small progress in this direction. But since 1949/50 the acreage given over to rice cultivation has expanded by less than one-fourth, most of the new land being of relatively low productivity.

Reduce demand. In addition, there are possibilities of lowering aggregate domestic demand for rice. If the rate of population growth were to decline there would be some impact on demand, but there seems no likelihood that the death rate will rise, and there exists nearly as little likelihood that the birth rate will fall. There is a stronger possibility that the people's diet may be diversified through the introduction of new crops (preferably "upland" crops, which do not ordinarily compete for paddy fields) and new consumer tastes. Whether or not such dietary diversification will occur "automatically" with rising incomes and with emulation of upper-class and Western habits remains a moot point. From observation of Thai people's inclinations to favor their traditional foods even in the metropolis, it seems likely that any movement toward varying food intake will be a very slow process, unless stimulated by some strong and as-yet-unforeseen price incentive.

Diversify. A third possibility is to discover and encourage alternative exports. New exports will not only provide the foreign exchange used for meeting the same ends as that previously earned by rice, but they may eventually be able to pay for rice imports as population bypasses the nation's capacity to remain agriculturally self-sufficient. Development of new exports may help Thailand to shift toward industrialism, as rice specialization does not, and new exports may permit a certain amount of diversification of the industrial structure, which will increase the economy's adaptability to changing circumstances. A trend to diversification has been evident for a decade, although the stimulus for the surge in non-rice agriculture—particularly in "upland" crops such as maize, jute, kenaf, and tapioca—was not the pressure of population, but the incentive of higher prices afforded by new foreign markets. The rapid growth and diversification of agriculture may well have potential analogues in the industrial sector if they are properly exposed and nurtured.

The possibilities inherent in the three above-mentioned approaches—raising the rate of increase of rice production, lowering the rate of increase of domestic rice consumption, and diversifying the economic system to cope with the anticipated decline in rice exports—make the future seem not so bleak as statistical extrapolation connotes. With enlightened leadership there is no reason why, over the long run, the Thai economy may not sustain its relatively high growth rate despite the structural shift away from rice as the economic mainstay.

But that is the long-run view. In the immediate future there are certain to occur sharp repercussions from the Malthusian squeeze on rice. Neither techniques of agricultural production, trends of population growth, habits of consumption, nor the underlying pattern of industrial activities can be expected to change overnight. The possibilities mentioned above could prevent a rice crisis only if the crisis only if the crisis were attacked perhaps as much as a decade beforehand. As it is, with the crisis near at hand, the possibilities must be applied now and continuously for some years to come in order that they may remedy the impending crisis at the earliest possible moment.

[Condensed from "The Malthusian Squeeze on Thailand's Rice Economy," Asian Survey. Berkeley: Institute of International Studies, University of California, Vol. VII, No. 7, July 1967, pp. 469-481.]

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FAMILY PLANNING FOR AFRICAN WOMEN

Grace Ogot

[From the African woman's point of view, contraception has serious drawbacks. Rumors and counter-rumors feed her fears that it will impair her ability to produce children, her sole justification in the eyes of society. No family planning program will succeed unless it can take account—tactfully and patiently—of these fears.]

To the African woman, whether educated or uneducated, childbearing is still the sole basis of a happy and a permanent marriage. In most African societies, up to this very moment, if a woman does not become pregnant soon after her marriage, or if three or four years pass before she becomes pregnant again, she invariably becomes the target of village gossip and speculation; she is suspected of having contracted a bad disease, or of having committed a sin for which she is being punished by God. If the woman cannot have a baby, she is doomed; she is despised and humiliated. If the woman is allowed to stay with her husband when he marries a second wife, she faces all the unjust accusations of causing sickness to the co-wife and her children.

School education and Western civilization have not changed the man's attitude on childbearing much. Underneath, he still believes what his great-grandfather believed. Most men want a male child. A man whose wife can only produce daughters, even if they are ten, has no time for the theory of "one man one wife"—he must have a son.

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With such impossible demands, the woman in Africa cannot escape the challenge society has put upon her. Right from girlhood, she regards the baby as the axis of life on which her whole world rotates. It is the baby which makes her marriage secure and on which her happiness depends.

This I think is the man reason why African women are skeptical about the Western idea of family planning—i. e., of using scientific devices to stop birth temporarily. They fear the unknown. They fear that interfering with reproductive organs may result in not being able to have babies when they want to and thus render themselves useless in the eyes of society.

Rumors, Counter-rumors, and Questions

By 1960, the pill was being used in East Africa by a handful of educated women who got them through their doctors. The pill cost between seven and twelve shillings a month, so that only the well-to-do could afford it. But it was not only the price that stopped many East African women from taking the pill. They were afraid. Some people started a rumor that it was a new drug Wazungu (Europeans) had manufactured to sterilize African women; and there were rumors and counter-rumors about the death toll of European women who had died from bleeding and thrombosis. Some women were not deterred by these rumors. They liked the pill because you needed no strenuous preparations; you swallowed it and then forgot all about it. Some women even swallowed the pills behind their husbands' back

But the pill, though easy to take, has not gained much popularity among the African women. Almost more than half of the women who were taking the pill two years ago are no longer taking it today. Some stopped because they suffered from heavy and irregular bleeding; as a result they became anemic, tired, and perpetually worried that they may bleed to death. Others missed their periods for one or even two months. One mother of a three-months-old baby nearly worried herself to death that she was pregnant, only to see her period a month later; by this time she had lost all her breast milk. She decided to abandon the pill. Then there is the group that stopped because of nausea, headache, dizziness, backache, and pain on breasts.

Until the Planned Parenthood World Population Association published its report in April, 1965, we in East Africa assumed that these complications were suffered by women all over the world. But this report proved beyond doubt that the way our women have reacted to the pill here in East Africa is quite different from the reactions of women overseas, who had few such complications. At the same time, we cannot dismiss as superstitious the genuine complications that have been noted by East African women. We need more research in this field.

While the pill debate was still continuing, another contraceptive reached East Africa. It was the IUD, or coil. But the doctors have insisted on getting written consent from the husband before inserting it. This, of course, presents a problem. Since its introduction to East Africa, only a handful of educated women have been able to get their husbands' consent to wear an IUD. The majority have not the courage to try it yet.

The coil has caused a lot of misgivings and talk among men and women in East Africa. Unlike the pill, most men are opposed to the idea of their wives wearing it; some of them claim that the tail of the coil that is usually left hanging up in the female canal bothers them. Another thing that has caused quite a scare is the possibility of becoming pregnant while wearing the coil. Many women ask: Can a baby conceived while the mother is wearing a coil be normal? For the coil being a "foreign body," many people feel it may deform the baby. They ask: Is the coil pulled out when the mother becomes pregnant? If so, is there a risk of causing abortion? And they worry: Does this woman stand another chance of wearing the coil without being pregnant again? Many women wearing the coil have also experienced a lot of bleeding, backaches, and discharges. All these difficulties lead one to think that, although the Family Planning Association figures show some increase in insertions, the figures of women having their coils pulled out each month may be quite high, too.

The other contraceptives have drawbacks, too. The cap (diaphragm) has never been popular with East African women, for its use needs skill and patience; furthermore, it has failed many women because it was not well fitted. Stories circulate that foam tablets cause erosion of the birth canal and eventually cause cancer; this allegation, of course, has no medical evidence, but the village people firmly believe it. Condoms—better known as Kabuti (raincoats) have been in East Africa for a long time, but many men don't like them; they complain that they act as a barrier between them and their wives. Quite a number of women also complain that these rubber sheaths bruise them a bit and that they make intercourse one-sided.

Advice for Family Planners

Now, it is important to say that quite a number of families would like to seek the advice of family planning experts to help them space their children. It is reported that the Family Planning Association of Kenya, Nairobi Branch, had a 40 percent rise in attendance at its 17 clinics in the year ending June 1966, going from 8,228 in 1965 to 11,487 in 1966. But the idea of having fewer children for the sake of giving them better education and better standard of living has not caught on in East Africa. Five, six, seven children is considered quite a small family.

Kenya has been warned that an annual rise of 3 percent will in 18 years have doubled its population. But whereas our children will readily appreciate the meaning of population explosion, 90 percent of the present generation will find it next to impossible to accept a scheme for birth control, regardless of how alarming the rise in population may be. The Family Planning Association, even with the backing of the Government, clearly has a very difficult task.

But agreeing that we have to start somewhere, the following points are worth bearing in mind:

1) Over-enthusiasm on the part of the Family Planning Association and the Government may spoil their case. Even the elite group hate to be lectured to about the number of children they should have. Tact and working quietly may yield more fruit than numerous public speeches.

2) The Association should make use of women for family planning talks at the headquarters in Nairobi. They can achieve much more than the strong team of men we have now. And women field workers should be those of high integrity.

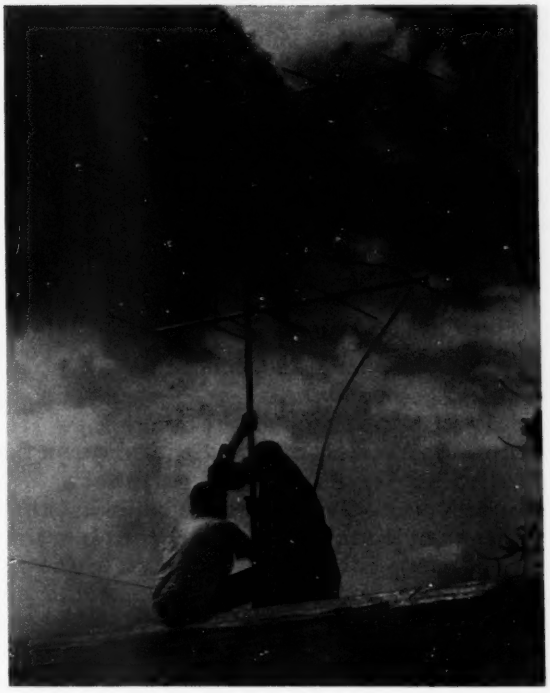
3) A research department must be set up immediately to find solutions to the numerous problems facing East African women in connection with contraceptives.

4) Foreign experts should refrain from issuing alarmist statements about population problems in Kenya. Colonialism is still fresh in people's minds and it would, therefore, not be difficult to interpret the foreign experts' over-enthusiasm for family planning in Africa as a kind of neo-colonialist trick to keep the African population down. Indeed, one correspondent in the East Africa Journal, November 1966, has already said this. He suggested that East Africa should have as its motto: "Largest in quantity and best in quality."

[Adapted from East Africa Journal. Nairobi: East African Institute of Social and Cultural Affairs, Vol. IV, No. 4, July 1967, pp. 19-23.]

EDITOR'S NOTE: To help family planning field workers, the East Asia Office of The Population Council in Taiwan has prepared a pamphlet answering the most commonly asked Questions. . . about Loop and Pill in language simple enough to be clear to the layman. This pamphlet is available gratis from Mr. S. M. Keeny, The Population Council, P. O. Box 112, Taichung, Taiwan.

THE NEW MEDIA IN EDUCATION



What we are building now is the nervous system of mankind.... The communications network, of which... satellites will be nodal points, will enable the consciousness of our grandchildren to flicker like lightning back and forth across the face of this planet. They will be able to go anywhere and meet anyone, at any time, without stirring from their homes... all the museums and libraries of the world will be extensions of their living rooms.... And it will not matter where those living rooms may be; for on this planet at least, the conquest of space will be complete.

[Arthur C. Clarke, "Prediction, Realization and Forecast," Communication in the Space Age, p. 38. Paris: © 1968 by UNESCO.]

THE NEW MEDIA IN ACTION

Guy Benveniste

[New technology has dramatically broadened the horizons of education. Radio, television, films, and programmed instruction can often be used to good advantage in developing countries, as long as the cost issues are faced squarely.]

The rapid expansion of education all over the world is not without its problems. When too many new schools are created and trained teachers are not available, the result is often poor quality education. When the goals of education are changed as its base is broadened, existing curricula are often found to be ill-adapted to modern and different needs. When educational policy makers try to do something about changing the content of education and improving the training of teachers, they soon discover that educational systems are slow to respond and that money and human talent are simply not available on the scale required.

It is in this context that we must consider new educational technologies—particularly radio and television and programmed instruction. Most developing countries have been experimenting with one or more of them. Encouraged by sources of external aid, pilot projects in educational television dot the globe, a fair number of school radio programs are under way, and here and there small groups of experts are attempting to design programmed materials for use in developing countries.

Algeria is using television and other audio-visual aids for teacher training and supplementary teaching [see pp. 61-65]. Colombia is attempting to use television to upgrade primary school teaching [see pp.

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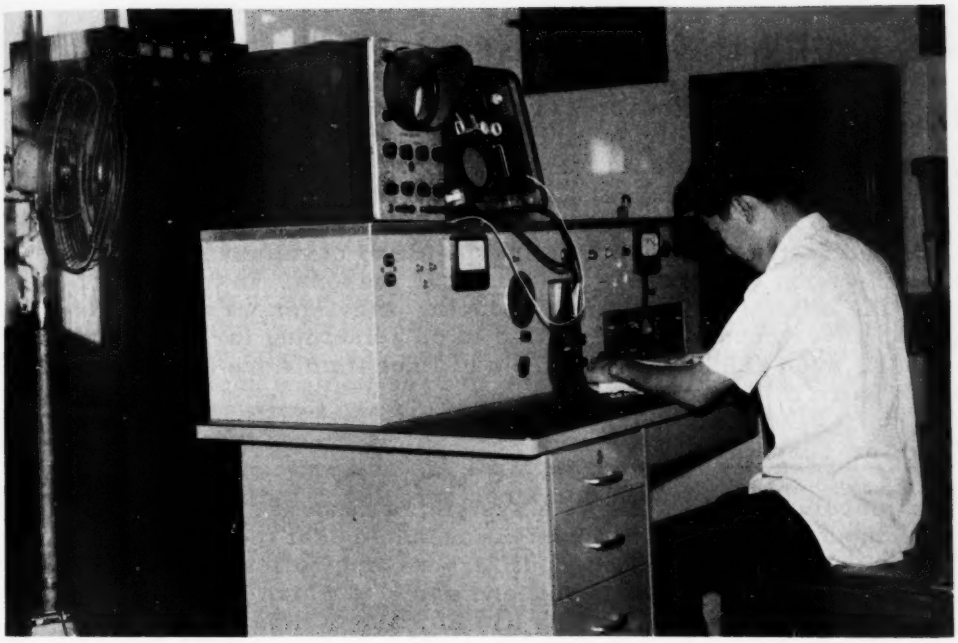

The faculty and students of the Bangkok Technical Institute built this master control room for Thailand's school radio broadcasts; the broadcasts are now used by about 5,000 schools and 800,000 students. (photo: courtesy of IIEP)

54-60]. In Brazil, a UNESCO regional course to train experts in the use of programmed materials for new physics courses has been running for some time. In India, the Radio Rural Forums have played a role in rural modernization for several years [see pp. 66-73], and experiments with educational television are going on in the Delhi area. In Niger, experiments with Radio-Vision combine the use of radio with visual aids in adult education [see pp. 74-77]. In Nigeria, television is being introduced in primary schools. In American Samoa, an integrated television school system has been created. And in Thailand, a national radio program to upgrade instruction is well established. Many more examples can be cited.

All these projects have certain characteristics in common. They have usually benefited from external aid, not only from bilateral and multilateral aid-giving agencies but also from private broadcasting organizations. As a rule, they were designed in the light of experience acquired in more advanced countries. Some well-established radio programs now reflect rather more indigenous than foreign experience, but educational television in developing countries is still heavily influenced by European, American, or Japanese experience.

At the beginning of 1966, it was difficult to find a single on-going pilot effort using programmed instruction in the schools of a developing country, although a few programs in industry and government are known to exist and some training courses for programers. In contrast, there are instructional television pilot projects in some forty developing countries. The reason for this striking difference may have less to do with the fact that instructional television pre-dates programmed instruction than with the desire of developing countries to have television for prestige and political reasons. In many instances, the official reason for introducing television was education and so the government felt committed to do something for the schools; as a result, even reluctant Ministries of Education were soon involved in one or more pilot projects.

Teachers or Teaching?

If we conceive of education as a system, we can say it has two principal inputs: teachers and various technological tools. For any learning task, there may be many different combinations of these inputs, some of which may work well and some of which may be failures. The combination of technology plus use of teacher time that suits a developing country may be quite different from the combination that suits a wealthier country. If there is a shortage of teachers, it is pointless to copy another country where educational television or other technologies are used simply to improve or complement the presentation of the teacher.

If educational radio or TV is being considered for a developing country, one must think in terms of: acceptance on the part of teachers, parents, students; achieving cooperation between the different ministries that may control the media and education; getting teachers trained to use the media in a classroom situation; creating or adapting school programs; and acquiring and establishing the necessary receiving and transmitting facilities. And most important, sooner or later planners and administrators must think in terms of costs and financing.

What Will It Cost?

It is not possible to say categorically that any one educational technology can or cannot be used in developing countries, because the cost of the technologies is not clear cut (although, for the moment, at least, using computers in the classrooms of developing countries seems prohibitive). Today we assume that educational films, radio, television, and programmed materials, when properly used, may well be within the feasible cost range.

A review of a significant sample of on-going instructional television systems in Europe, Japan, and North America indicates that very small systems serving a few schools or buildings, such as one university, tend to have annual operating costs of around $100 per hour of instructional television. Middle-sized systems, such as interconnected closed-circuit systems serving a middle-sized town and adjoining region, need something like $120,000 a year (about $300 per hour) to produce, transmit, and distribute 400 hours of instructional television. And networks serving a large portion of the territory of middle-sized countries seem to need budgets of about $2 million ($5,000 per hour) to do the same thing. Thus, if a developing country felt that it could spend, say, $10 a year per student to provide instruction by television, a small system would need 4,000 students to be viable, a middle-sized one 12,000, and a national network 200,000.

These minimum sizes do not seem impossible. It makes little sense to assume that developing countries cannot afford some of the new educational technologies. Equally, one cannot assume that the approach that works in richer countries, where costs may be of more limited importance, will also work in developing countries. Even when pilot projects have been successful, if they were not designed in terms of cost feasibility, it has proved very difficult to move on to large-scale operations calling for considerable budgets.

The new educational technologies can be used intelligently in developing countries if the cost issues are faced squarely. The new technology may permit teachers to do much more in the available time. It may help meet shortages of trained teachers by substituting for them where they are not available. It may help improve the overall quality of education by sharing the best teachers or the best teaching among many more pupils. It may permit more rapid modernization of the content of education, which becomes possible through the intensive and accelerated training and retraining of the existing pool of teachers. Finally, it might be used to create totally new forms of education and training particularly suited to the necessities of modernizing countries.

[Excerpted from "The New Educational Technologies and the Developing Countries," The World Year Book of Education 1967: Educational Planning. London: Evans Brothers Limited, 1967, pp. 375-381.]

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USE OF THE NEW MEDIA

United Nations Educational, Scientific,
and Cultural Organization (UNESCO)

[Use of the new media often requires revamping and re-examining an educational system. In addition, it calls for planning, training, inter-agency cooperation, and audience research.]

In today's educational process, radio and television have a privileged, though not of course isolated or self-sufficient, importance in developing countries. Nevertheless, broadcasting requires considerable initial investment and continuous operating expenses for personnel, programs, and receivers. Such expenditure is justifiable only if it promises to yield important results which could not be obtained by other means.

While each medium has its own characteristics, assets, and limitations, the broadcast media share certain features which enable them to make a special contribution: They are independent of traditional ground communications and can reach any place anywhere (particularly once space communications are being used), unhampered by mountains, swamps, and deserts. Everyone can receive their message—literates and illiterates alike. Their instantaneousness and flexibility of production enable them to adapt quickly to changing ideas and conditions. They address themselves to the entire personality of the listener or viewer, as their programming can range widely over information, education, and entertainment. They have both emotional and intellectual appeal and can thus be powerful agents of motivation. They can both penetrate into the intimacy of the home or act as agents for group formation and community action. Radio is relatively cheap in production and reception and does not depend on the availability of electricity. Television, while more expensive, makes up for its cost through more profound impact.

Inevitably, these important assets are accompanied by certain deficiencies. The broadcast media lack the spontaneous interaction of teacher and student; they lack the permanence of the printed word; they lend themselves to centralization and do not adapt easily to local conditions and preoccupations; they require a technical infrastructure and suitable maintenance. These and other limitations underline the importance of combining their use with other communication media and underpinning them with an organizational and maintenance structure.

Planning

There is often, and for basically excellent purposes, a tendency for broadcasting organizations to lead an existence of their own, to have little contact with other governmental or private organizations engaged in public affairs. The use of radio and television for education and development, however, is only possible if there is close integration of the efforts of all concerned.

The possibilities inherent in educational broadcasting make it worthwhile to restructure education so that it may make the maximum use of the expensive facilities required. Methods of teacher training will have to be re-examined in the light of these new resources. If there is assurance that young teachers will be able, wherever they are working, to have continuous in-service training by radio and television, coupled with correspondence teaching, the preservice training may be shortened and reoriented. In the classroom, television can play a significant role in the teaching of science and mathematics, as well as language, geography, and history. It might even be possible to meet the pressing lack of teachers and schools in certain areas through the creation of schools organized around a television receiver; these could carry the main burden of overall instruction—along the lines of the school system in Samoa, the Television High School in Japan, or Telescuola in Italy.

In adult education, coordination is more difficult to assure because it rarely disposes of the same institutional structure as school education, where responsibility normally lies with a single ministry. In the absence of such a structure, coordination at an early stage by the educational planning bureau is even more urgent. When the bureau envisages providing adult education in literacy, social education, community development, etc., it will necessarily have to examine the various resources which might be brought to bear. These resources will include professional educators but will also involve other ministries (agriculture, health, etc.) and the mass media, particularly broadcasting. In short, adult education will have to be part of overall national planning.

From the point of view of broadcasting organizations, educational programs will equally have to be planned in coordination with administrations responsible for education and development. Only in this way can broadcasters hope to obtain collaboration in the form of financial assistance, the presentation of content in programs, and the utilization of these programs, including the provision of receivers.

Sound planning will save both money and manpower in production and application. It is in the planning process that answers will have to be found to such questions as:

What investment in installations and equipment is required to assure availability of broadcasting for educational purposes?

What legal, administrative, and financial provisions should be made to facilitate close cooperation between broadcasting organizations and agencies of education and development?

What training programs must be envisaged?

What organizational infrastructure is needed to ensure cooperation between broadcasting and other educational efforts in all their phases, from presentation to utilization?

What provision will have to be made in industry to ensure the supply and maintenance of receiving equipment?

Production

Cooperation between broadcasting organizations and agencies of education and development in the production of programs is essential, though frequently difficult to attain. A number of preliminary questions will have to be answered which are linked to the very structure of broadcasting: Which institution is providing the facilities (studios, technical personnel, creative talent, film facilities) for program production? Where does responsibility lie for the content of the programs? What agency carries the budget for the necessary staff and operational expenditures? What provisions are made, and by whom, for the training of staff skilled in the presentation of educational content?

In answer to these questions, different patterns have evolved throughout the world. In some cases, the entire responsibility rests with broadcasting organizations, which assure liaison through consultative bodies of educators. In other cases, educational authorities take over complete responsibility, even for transmission itself (through stations serving educational purposes exclusively). Then there are intermediate patterns: broadcasting organizations may

In Niger, reading, writing, and arithmetic are being taught by TV in the first year of primary school. (photo: Almasy)

undertake the technical production of programs that are planned, written, and produced by outside agencies; educational agencies may produce programs in whole or in part for transmission by the broadcasting organization; educational authorities may make funds and staff available to the broadcasting organization for the production of educational programs.

Whatever the particular pattern adopted, certain general rules seem to apply: there is a need for professional staff to be skilled in broadcasting and familiar with the content and methodology of educational presentations; production services specifically earmarked for educational purposes must be continuously available; and there must be machinery for close liaison between broadcasting organizations and the various agencies responsible for education and development. Such liaison is required even when educational authorities operate a broadcasting station, because the field of adult education extends considerably beyond the normal competence of educational administration.

Furthermore, certain psychological obstacles have to be overcome. It is normal for professionals in the field of broadcasting to assume that they are specialists in the presentation of information and entertainment, that they know best what will appeal to the audience and how the resources of the medium should be employed. Specialists in education and development, on the other hand, stress with confidence that they must be the sole judge with regard to the content of programs. Content and form, however, are so closely intertwined that

fruitful results will, in the long run, only be obtained through a staff which is thoroughly familiar with broadcasting techniques, educational methodology, and, to a certain extent, educational content (though the latter may be enriched through resource persons in various fields). The emergence of the "amphibious" educational broadcaster as a distinct new profession has been observed in many countries.

Reception

Reception is frequently the most neglected aspect of broadcasting. Practice shows, however, that it is perhaps the most important. For educational broadcasting works in a vacuum as long as conditions of reception are inadequate. To create favorable conditions calls for cooperation between:

the Ministry of Communications, which must assure coverage of the areas to be reached;

industries producing receivers and their components, which must assure an adequate flow of radio and television sets at reasonable cost and suited to educational uses;

the financial authorities, which should attempt to arrange customs and tax levies so as to favor the educational use of broadcasting;

the broadcasting organization, which must arrange its schedule so that enough programs, at suitable times of the day, can be broadcast to make it worthwhile to purchase receivers for educational use. In many cases, broadcasters may be called upon to supply the receivers themselves;

agencies of education and development, whose arrangements at the receiving end can greatly enhance the value of educational broadcasts for the listeners.

In Asia, the use of radio and, even more, television, for educating a large portion of the population seems possible only under conditions of group reception. There is an audience relations aspect to such reception which is vital to effective use of radio and TV for education. Group leaders (who should be literate) must be trained in techniques of organization, directing discussions, and reporting. Furthermore, the fleeting message of the radio or television program is far more effective if it is supported with written material which permits adequate preparation for the program as well as follow-up, including the answering of questions. Particularly important is provision for the distribution and maintenance of receivers. Experience

in Asia shows that receivers distributed by government authorities frequently have a short life due to lack of provision for repair and replacement of batteries.

Broadcasting unquestionably suffers from the handicap of being a one-way channel of communication, from the center out to a dispersed audience. But in group reception, trained teachers or group leaders can transmit regularly to the broadcasting organization written reactions, questions, and comments, which in turn may be answered in subsequent programs. Such feedback enables the broadcaster to adapt himself better to the preoccupations of the audience and provides valuable information on local conditions. Even more important, it gives the audience a sense of participation; rather than being a mere object for broadcasts from authorities far removed, the listener or viewer senses better his own share in the common effort.

In addition to this continuous flow of reactions, a more general systematic sampling of both individual and group audiences, which gives not only quantitative results but also an insight as to the comprehension of programs, is vital for the use of broadcasting. Such research can be undertaken by the broadcasting organizations themselves or by independent agencies or academic institutions. The heavy investment required for educational broadcasting is justifiable in the long run only if periodic evaluations show the results and indicate weaknesses.

Training

Broadcasting's full potential as an instrument of education can only be realized when training is successful on four levels:

general training of professional broadcasting staff;
special training of broadcasters in the production of educational programs;
training of educators in the organization and production of programs;
training of teachers, adult education leaders, and others in the utilization of programs.

These forms of training may also be seen not as separate alternatives but as progressive stages in a broadcaster's development. Educational use of broadcasting obviously calls for instructors with a full understanding of both the broadcast media and the educational process.

In addition to programs aimed specifically at professional training in educational broadcasting, certain related projects can make significant long-range contributions and create a pool of personnel from

which professionals may subsequently be drawn. Thus, training in actual use of the broadcast media is gradually becoming a regular feature of teacher-training institutions. The use of film, tape recorders, radio, and sometimes even closed-circuit television in school systems and universities, can provide not only familiarity with techniques, but create early awareness of these media as forms of modern expression and sources of possible careers in the future. The very use of broadcasting in the educational process helps to condition both teachers and students to their importance. Including the results of audience research in social science courses can also bring about a wider understanding of the implications of broadcast programming.

[Excerpted from, "The Application of Broadcasting to Education and Development," Reports and Papers on Mass Communication, No. 49: Radio and Television in the Service of Education and Development in Asia. Paris: UNESCO, 1967, pp. 12-28.]

ON THE DIFFERENCE BETWEEN TV AND RADIO

by Marshall McLuhan

In a group of simulcasts of several media done in Toronto a few years back, . . . four randomized groups of university students were given the same information at the same time about the structure of preliterate languages. One group received it via radio, one from TV, one by lecture, and one read it. For all but the reader group, the information was passed along in straight verbal flow by the same speaker without discussion or questions or use of blackboard. Each group had half an hour exposure to the material. Each was asked to fill in the same quiz afterward. . . . The students performed better with TV-channeled information and with radio than they did with lecture and print—and the TV group stood well above the radio group.

Since nothing had been done to give special stress to any of these media, the experiment was repeated with other randomized groups. This time each medium was allowed full opportunity to do its stuff. For radio and TV, the material was dramatized with many auditory and visual features. The lecturer took full advantage of the blackboard and class discussion. The printed form was embellished with imaginative use of typography and page layout to stress each point in the lecture. All of these media had been stepped up to high intensity.

Television and radio once again showed results high above lecture and print. Unexpectedly to the testers, however, radio now stood significantly above television. It was a long time before the obvious reason declared itself, namely that TV is a cool, participant medium. When hotted up by dramatization, . . . it performs less well because there is less opportunity for participation. Radio is a hot medium. When given additional intensity, it performs better. . . .

A cool medium, whether the spoken word or the manuscript or TV leaves much more for the listener or user to do than a hot medium. If the medium is of high definition, participation is low. If the medium is of low intensity, the participation is high. . . . Because the low definition of TV insures a high degree of audience involvement, the most effective programs are those that present situations which consist of some process to be completed. . . .

[Excerpted from Understanding Media: The Extensions of Man, pp. 311-319. © 1964 by Marshall McLuhan. Reprinted with permission of McGraw-Hill Book Co., New York.]

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COLOMBIA: TV FOR PRIMARY SCHOOLS

Jack Lyle, et al.

[Use of television in Colombian primary schools has stimulated changes in courses and teaching methods. It has emphasized once again, however, that the amount of learning from TV depends greatly on what happens in the classroom before and after the broadcast.]

With considerable external help, Colombia has mounted one of the world's largest instructional television programs. Approximately 13 percent of its primary school pupils are receiving two 15-minute lessons a week in "new math" (all five years of primary school), natural science (four years), language (three years), social studies (two years), and/or music (grade 1 only)—subjects that most needed the visual aids that Colombian classrooms rarely have. The ultimate aim of the lessons is to provide the student with a richer, more stimulating environment for learning and to lead him to more active participation in, and a more positive attitude toward, education. In addition, teacher orientation programs are broadcast two hours a week to guide teachers away from traditional techniques of straight lecture, repetition, and rote memory toward more dynamic methods.

Although the present program dates only from 1964, two previous attempts to use television for school purposes were made. It was first tried in 1955, shortly after national television came to the country, but was abandoned within a year when a revolution removed the president, its chief source of

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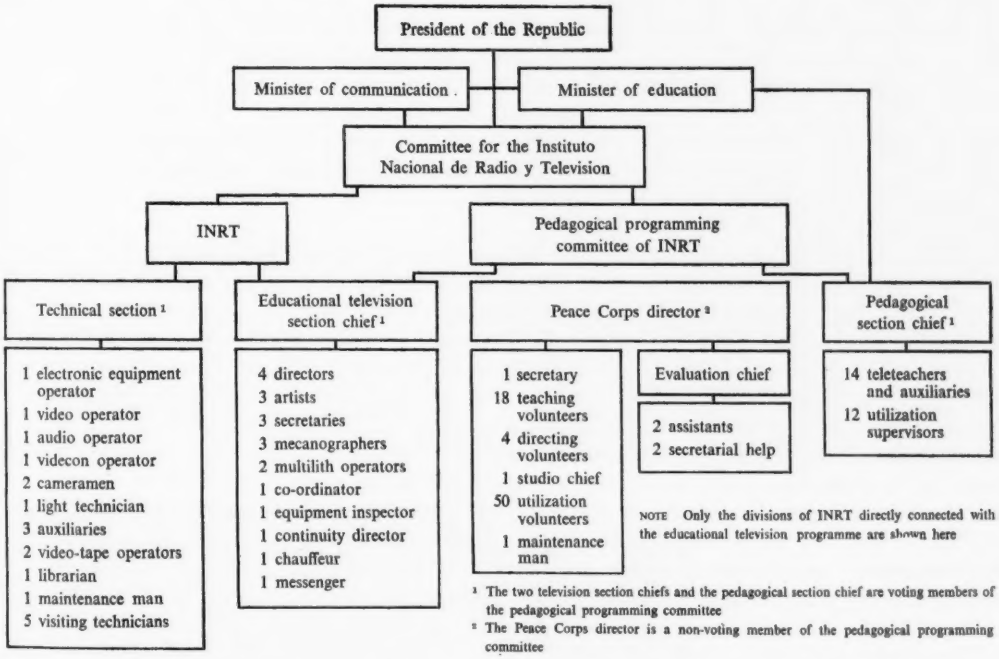
support. A second trial, in 1961/62, fell victim to one of the country's periodic financial crises. When faced with budget cuts, neither the ministry of education, which felt that educational television was really a program of the ministry of communication, nor the ministry of communication, which felt that education was not its central function, would support it. The current, better integrated program is financed by five agencies: the INRT (the government-owned national television network), the ministry of education, the six local departments, the US-AID, and the Peace Corps. A $575,000 grant from AID paid for 1,500 TV receivers and other equipment. Eighty Peace Corps volunteers help in all phases of the program.

In all, over 130 persons are directly involved in the preparation, production, and utilization of the educational television program, as shown in the following table of organization.



NOTE Only the divisions of INRT directly connected with the educational television programme are shown here

[1] The two television section chiefs and the pedagogical section chief are voting members of the pedagogical programming committee

[2] The Peace Corps director is a non-voting member of the pedagogical programming committee

Lesson Preparation

The teleteachers—all certified teachers paid by the ministry of education—write and present their own lessons. Aside from problems associated with learning the technology of television, they have found it necessary to adjust to certain limitations inherent in the use of TV for teaching purposes. For example, the camera does not offer the immediate stimulus of pupil reaction as a guage of effectiveness, timing, etc. The size of the audience reached means that

teachers must try to strike an average, even though teacher and student competence varies greatly across the country and even within individual schools. Furthermore, the rigid 15-minute format leaves little room for variation of approach or expansion of points. Classroom teachers have periodically been asked to return questionnaires designed to mitigate some of these problems, but response has not been high.

All lessons are taped in advance of broadcast. This will help reduce the number of lessons that need to be re-produced each year and should enable the same staff and resources to handle an expansion of total content. More important, videotaping will permit the teleteachers to visit schools and see the lessons actually being used; the pressure of preparation has restricted this much-needed activity in the past.

The lessons are not of equal quality, even within the same series. The pedagogical approach—designed to minimize opposition from the classroom teachers and old-line ministries—is still out-dated and over-concerned with the presentation of simple facts. Nevertheless, learning and improvement on the part of the educational television staff are obvious from a comparison of the quality of the early programs with those being used at present.

Despite lack of funds and, in some cases, advance planning for obtaining visuals, particularly on-location films, the teleteachers have used a wide range of aids—flannelgraphs, pictures, models, maps, animals, puppets, action films and slides, various pieces of scientific apparatus, etc. Both teleteachers and classroom teachers in the participating schools say they have learned a great deal about improvising visuals from material at hand. Indeed, one of the features distinguishing participating schools is the presence of visual aids that students and teachers have made in direct reaction to the television classes. Striking examples are the percussion bands which Grade I classes have formed, under the leadership of the teleteacher, using such common items as tin cans, scraps, lumber, and nails as components of "instruments."

Teacher Guides. One of the most important factors in the television lessons is the guides for classroom teachers that are prepared by an auxiliary teacher in consultation with the telecaster for the course. These are distributed to all participating schools. In addition to information on scheduling and the like, the guides offer concrete suggestions and advice on problems that might arise and activities that might be stimulated by the broadcast. Furthermore, if a class misses the broadcast, the teacher can use the guide as the basis of his own lesson, so that continuity is not lost. Not all the teachers make full use of the guides; those that do seem to find them most useful for the follow-up work.

Above: A telemaestra (or teacher actress) rehearsing a lesson.

Right: Assembling the television aerial for a village school.

Bottom: The Peace Corps "utilization" volunteer reviews student notebooks. (Photos here and p. 41 courtesy Peace Corps)

As the number of schools in the program grows, more efficient control will be needed to ensure an adequate supply of proper guides. Delay anywhere along the line leaves teachers without guides for the first, critical lessons of the term. Indeed, lack of guides has been the most frequent criticism of the entire program.

Production

Production of each course is supervised by one Colombian director (who is a teacher) and one Peace Corps volunteer. They are rotated from one lesson series to another, and each member alternates as director and video console operator, so that problems of replacement can be eased. One of the Bogotá universities is adding principles of educational television to the audio-visual portion of its teacher-training course to provide a reservoir of candidates for this work in the future.

All technical personnel are provided from the regular INRT staff. The frequency with which they have been changed has caused considerable dissatisfaction among the educational television people, who would like to have their own technical division which could become integrated into the overall educational effort.

Utilization

Evaluation of the program in Colombia verifies results found elsewhere: The amount of learning from television depends to a very great extent on what happens in the classroom before and after the broadcast. When the teacher can be persuaded to depend less on rote learning and, instead, to encourage the pupil to participate more actively, a significant increase in learning takes place. While the television lessons are designed for use by the "average" teacher, even the better-trained teachers told us that they found using the lessons a strain at first. This fact has made the work of the "utilization teams"—about eight Peace Corps volunteers and two Colombian supervisors per department—crucially important.

The utilization teams—effectively, the Peace Corps volunteers—serve as official links between the educational television staff and the classroom teachers. They visit prospective schools, supervise the installation of receivers, and brief school authorities and teachers on recommended classroom arrangements and procedures. They also coordinate the repair of broken sets.

More importantly, however, the teams advise on ways to provide an effective context for the television. They check through the students' copybooks. They talk with the individual classroom teachers, answering questions, giving suggestions and encouragement, and

obtaining reactions to be passed on to the production and pedagogic staffs. It has been found that the most effective television lessons have been those where students had systematic contact with the utilization personnel—apparently, because the teams stimulated group discussion and the keeping of notebooks.

As the program has progressed, increased emphasis has been given to good viewing conditions. Schools are now required to construct a base for the receiving set according to specification prior to its installation. Where viewing conditions are poor and no effort is made to correct them, existing sets are withdrawn. This rule is a result of such unhappy experiences as failure by some school officials to follow through with promised construction, appropriation of the set for private use by headmasters or caretakers, and theft. Unfortunately, the rule tends to discriminate against isolated rural schools, but those in charge of the program feel that they must maximize evidence of solid accomplishment in order to guarantee the program's survival and expansion to other schools.

Physical problems have been many. Frequent power failures, overcrowded classrooms, and difficulty in darkening classrooms have each been reported by at least a third of the participating teachers. The existence of a national television transmission network which can reach the great majority of schools gives the program tremendous advantages. However, lack of electrification in many smaller, isolated schools, and the erratic electrical service for many schools that are wired, remain serious problems both for expansion and for dependable utilization of television lessons. As of late 1965, some 809 of the 1,500 sets donated by AID had been distributed. The most pressing factors slowing expansion were government restrictions on imports of television receivers, repair parts, videotapes, and other supplies and the lack of funds for purchase of additional sets once those supplied by AID had been issued.

Prospects

The serious question for the future is whether the program can survive when the external aid commitments expire. The present Peace Corps director feels that the latest group of volunteers should be the last, and when they leave the program should stand or fall as a strictly Colombian venture. There is personnel capable of continuing the program, but there is some question whether they will be given sufficient appropriations to carry on.

Estimated current costs of the program are shown in the accompanying table. (The cost of Peace Corps volunteers, over 60 percent of the personnel, has been here computed as if Colombian personnel had taken over their functions; actual costs were 7.75 million pesos

higher.) This total of 13.26 million pesos, covering 275,000 students and 318 hours of broadcasts, amounts to about $2.68 per student, though this estimate is based on the official exchange rate of 18 pesos to the dollar. (This is thought to understate the true cost of the program by about 20 percent.) Total investment in program production, transmission, and reception is about 32 million pesos, or $6.47 per student. Costs per student-hour are thus about $.13 in investment and $.05 in current costs. Per hour of broadcast per km^2, costs are $.08 and $.03 respectively.

TABLE Estimated current costs of educational television in 1965 (in pesos thousand)

	Staff	Other current	Depreciation	Interest[1]	Total	Percentage
Programme production and administration	1 886	314	1 384	637	4 221	31.8
Transmission	2 000	459	1 664	1 496	5 619	42.4
Reception	1 471	435	1 087	423	3 416	25.8
Total	5 357	1 208	4 135	2 556	13 256	100
Percentage	40.4	9.1	31.2	19.3	100	

1. Current rate for bank loans being 16 per cent, a flat 8 per cent has been applied to original investments as an appreciation of average interest per annum

The Colombian participants in the program are optimistic. Indeed, they talk not only of expanding their own program, but of setting up a training center in Bogotá for personnel from other Latin American countries. Perhaps the greatest hope for the program's continuation and growth, as well as one of the most gratifying aspects of its present situation, is its expanding support among the teachers into whose classrooms it is now coming. Fully two-thirds of these teachers say they would like to have more available.

The children are clearly learning more. But the total effect of the program goes far beyond this, because television is changing the classroom teacher. It is expanding the contribution of the individual teachers and making their classrooms more pleasant and exciting places for the children. This is immediately apparent to anyone visiting schools with and without the television program. Although teacher training is only a secondary responsibility of the program, it may in the end be its most significant contribution.

[Adapted from "Colombia's National Programme for Primary-level Television Instruction," New Educational Media in Action: Case Studies for Planners. Paris: UNESCO-IIEP, 1967, Vol. II, pp. 51-75.]

ALGERIA: FILLING THE TEACHER GAP

Jack Lyle, et al.

[Algeria is using a great variety of media—films, TV, radio, newspapers, and programmed instruction—to improve the qualifications of its teacher corps at the same time as it maintains a rapid expansion of its educational system.]

With great enthusiasm and resourcefulness—and very little capital investment—Algeria has mounted a many-pronged campaign to raise the quality of its primary school teachers. In the aftermath of independence, the government had recruited 10,000 moniteurs (a newly established rank at the bottom of the teaching hierarchy) to replace the French teachers it had lost and to cope with rapidly expanding school enrollments. Almost none of these were certified teachers; indeed, most of them had had minimal education themselves. Many were scattered in remote areas, with limited resources for self-study. There was also a language-culture problem, since about 30 percent of the monitors speak only Arabic.

Yet, the Ministry of Education had to put its new recruits in charge of classrooms at once. It is now undertaking to bring them up to minimum standards within four years through a variety of in-service courses. The institutional foci of these courses are the journées pédagogiques—which aim at improving teaching methods—and the Centres de formation culturelle et professionelle (CFCPs)—which concentrate on content. Teachers already certified and other interested adults are also included where appropriate.

A second article by Mr. Lyle and his colleagues appears on p. 54.

Teacher-Training Films

The journée pédagogique is an all-day session of local monitors and other primary teachers held once a week under the supervision of a Ministry of Education counsellor or inspector. Separate sessions are organized for Arabic- and French-speaking teachers. The emphasis is on proper use of didactic tools, especially for teaching French and Arabic, science, and mathematics.

To help demonstrate approved methods, the Ministry has made two films on the teaching of reading (one for French, one for Arabic) and a third demonstrating language teaching. UNESCO experts worked with Algerian educators and technicians in planning and making the films, which were then processed abroad (in the absence of local facilities) and distributed to each of Algeria's fifteen departments in multiple copies. Since the journées pédagogiques are usually held in a school already equipped with a 16-mm sound projector, no special purchase of equipment has been necessary at the receiving end. The accompanying table gives a rough idea of the costs involved.

TABLE Financial outlays and sources of finance for teacher-training films in Algeria (in dinars)

	Cash outlays	Deferred or notional payments[1]	Total
Investments[2]			
Ministry of education[3]	392 000	9 400	401 400
Unesco	17 400	9 200	26 600
Others[4]	—	30 000	30 000
Total	409 400	48 600	458 000
of which			
Expenditures abroad	211 900	36 100	248 000
Expenditures in Algeria	197 500	12 500	210 000

1. Pension rights and adjustments for overtime work
2. Production of the films and sixty copies each
3. Some of the ministry of education expenditures are financed through deductions from monitors' salaries
4. Local school boards, who have to finance the purchase of projection equipment independently

The films, shot "on location," show teachers selected for their ability actually teaching. Much of the sound-track consists of the classroom interchange between teacher and pupils; a commentary explains salient aspects of the methodology. From the standpoint of technique, the films are actually very simple; without attempting too much, they make imaginative use of available resources.

All the films are fairly long—forty-five to fifty minutes each. They compress a great deal of information, and it would be difficult to absorb them fully in a single viewing. However, they were designed for segmental use. Thus, a session may run as follows: The teachers and inspectors gather for their journée pédagogique. A film

sequence, lasting perhaps twelve minutes, is shown. The inspector calls attention to certain aspects of the technique illustrated in the segment and gives further explanation. Monitors may ask questions. Then the segment is repeated, and regular instruction resumes.

The film segment serves several purposes. Especially important, it illustrates classroom implementation of pedagogical technique by a skilled teacher. It gives focus to the comments of the inspector, and serves as a standard for evaluating the trainees' performance in teaching trials. Furthermore, the films have considerable interest in themselves, and so relieve what might otherwise be an exhausting session for all concerned. There has been no formal attempt at evaluation but the films seem to be very effective; more are planned.

Programmed Instruction and Television

The centers of cultural and professional education (CFCPs) offer adults after-work courses, both primary and secondary, in existing schoolrooms. Three hour-and-a-half sessions are held each week. In addition, CFCP participants automatically become subscribers to the Ecole du travail, which presents self-correcting courses in both French and Arabic versions. Although not exclusively for monitors, 140 of the 570 centers (in 1964/65) operate at the secondary level, which is appropriate for monitors working for advancement. The monitors' tuition is one of the items covered by a monthly salary deduction of ten dinars. [$1 = 8.33 dinars]

One of the CFCP's most interesting programs, in terms of teaching method, is a course in basic algebra begun in the winter of 1965/66. Stimulated by the shortage of qualified teachers of mathematics, this course uses a "programmed" text, coordinated with television teaching. Nobody seems to have told the Algerians that it was difficult to write programmed texts and that, despite a series of workshops, programmed learning was still not in school use anywhere else in Africa or the Middle East. And it must be admitted that the three self-study manuals the Algerians produced, aimed at those who have completed three years of primary school, are not formal Skinnerian programming. Nevertheless, they are built around the idea of eliciting active student responses and telling the student if he has responded correctly. The lessons included in the first manual are:

1. Vectors—addition of whole numbers
2. Subtraction of whole numbers
3. Algebraic sums
4. Addition and subtraction of numbers, whole and fractions
5. Multiplication and division of whole numbers
6. Multiplication and division of numbers, whole and fractions
7. Combined operations
8. Equations
9. Exponential powers
10. Operations using exponential powers

After a student reads a short text, he has a series of questions to answer, blanks to fill, problems to work. He can check his own answers.

The three French-language manuals comprise ten programmed lessons each. The programs were pre-tested and seemed to work well. When they were put into wide use they were further combined with twice-weekly televised lessons over the government's Radio-Television Algeria (RTA). The student works through his own lesson and then watches a television teacher review and expand on the basic concepts he has been studying. The half-hour television programs, extending over fifteen weeks, serve as a pacer to keep students on schedule.

Preparation of the entire course was directed by an official in the Ministry's department of pedagogy. This gentleman, a former secondary science teacher, had no formal training in programmed instruction, but spent about a year reading up on the method before writing the manuals with the aid of some secondary teachers and a pair of UNESCO experts. The same officer prepares and presents the television lessons. Some unavoidable difficulties in production have resulted from the general shortage of skilled television technicians, but in general, all concerned have cooperated wholeheartedly. Approximate current costs are given below.

TABLE Current cost of programmed instruction television course in algebra in Algeria (in dinars)

	Television course only	Total cost
Production and administration	12 400	30 800
Transmission	47 400	123 100
Reception	38 800	38 800
Publicity	—	9 800
Total	98 600	202 500

Monitors enrolled in the CFCPs and who live in the RTA reception area are expected to participate in the algebra course as part of their in-service training, and copies of the three manuals are automatically supplied to them. Other interested persons can participate, but they must buy their manuals through government libraries at a cost of four dinars each. In addition, a small amount has been budgeted for publication of the programmed course once a week in the three leading French-language newspapers.

Considerable publicity was given to the program to ensure attendance. The broadcasts are scheduled at an early evening hour so as to make watching as convenient as possible for the participants. In view of the dearth of private receivers, arrangements for group viewing have been made in the CFCPs, which are actually schoolrooms; this avoids the need for any separate investment in viewing

facilities. Official figures suggest that there are some 3,750 students taking the programmed instruction course and, of these, about 1,550—most of them monitors—have access to a television receiver. This percentage should expand as RTA expands.

Examinations are planned during the course to give those responsible for its preparation some idea of the amount of learning that is taking place, trouble spots, etc. Also, the directors of participating CFCPs meet monthly and teachers of mathematics in the centers are asked to give their reactions. Although revision of the programmed assignments would have to await a second edition, television presentations can be adapted immediately to solve emerging problems.

Correspondence Courses through Press and Radio

Correspondence courses, covering material up to and including lower-secondary level, are aimed particularly at monitors in isolated places. Lessons for these courses are printed each week in both French- and Arabic-language newspapers, and are supported by two weekly radio programs. One of the purposes of these courses is to enable monitors to earn the brevet, the minimum degree for rating as an instructor. Arrangements have been made for the students to take examinations for the appropriate certificates.

Summer Courses

Still another facet of the extra-scholastic program was the formation of the chantiers culturels, centers providing six to eight weeks of instruction for monitors during the summer. The chantiers are staffed with Algerian and French teachers, the latter provided under bilateral agreements with the French government. During the summer of 1965, 8,500 monitors attended courses at 34 of these centers.

Perhaps the most striking thing about the Algerian programs reported here is the combination of local initiative and imagination shown. These programs are problem-oriented. They were conceived and designed to attack specific problems using means already available. They also show a happy coordination of outside assistance. Foreign advice has made an important contribution, but that contribution has been well integrated into what have remained essentially Algerian projects. The authorities in the department of pedagogy are to be congratulated on their strong leadership and willingness to support innovation wherever it promises to help solve the nation's pressing problems of education.

[Adapted from "Two Uses of Mass Media for In-Service Teacher Training in Algeria," New Educational Media in Action, op. cit., Vol. II, pp. 159-177.]

INDIA: TEN YEARS OF RADIO RURAL FORUMS

Wilbur Schramm, et al.

[The radio rural forum in India has one very important lesson for planners: the road leading from a successful pilot project to a state- or nation-wide program may not be easy. Nevertheless, it is clear that the technique of reaching villagers through radio clubs can be a potent agent of economic and social progress.]

Early each Tuesday and Friday evening in some 12, 000 villages throughout India about a quarter of a million farmers gather to participate in a radio rural forum. They begin with a radio program, thirty to forty-five minutes in length, broadcast from a station of All India Radio. The program usually follows the same format: answers to questions sent in by the forums, news from the forums including reports on action projects that have grown out of the discussions, and then a presentation of the main topic of the day. This presentation may be a dramatization, an interview, a talk, a recorded discussion among farmers or between farmers and an expert. In any case, the program poses a problem thought to be of importance to the villagers and often makes constructive suggestions. When the presentation is over, the chairman leads the forum members in a discussion which typically lasts about thirty minutes and in any case is not permitted to go on longer than forty-five. The group is encouraged to decide on some action. If it does decide to take action or if it wants further information, this is reported back to the radio station by the convener, acting as secretary for the group. On a subsequent broadcast, the action is reported or the questions are answered. Thus the forum is designed for continuing two-way communication on development

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problems and plans, between the forum members in the village and the development officials associated with the forum broadcasts.

This rural radio program grew out of a pilot project undertaken a decade ago in the vicinity of Poona, in southwest India. There, in the spring of 1956, 144 radio rural forums were operated for ten weeks on a trial basis. Both by participant judgment and by scholarly evaluation, the experiment was a huge success.

Careful evaluation indicated that the average attendance at a meeting of a twenty-member forum was sixteen or seventeen, a very good showing. In an average forum, there would be three or four lively participants (especially leaders and conveners, but also others), with another ten participating occasionally. Literacy seemed to make very little difference in frequency of participation.

The measurements of learning from the forums were very encouraging. Persons who sat in the forums gained an average of almost six points between pre- and post-tests, whereas a control group of those who were not in the forums showed only slight gain—about one point, which was almost completely accounted for by non-forum villages that happened to have radios. Furthermore, these superior gains in learning were not restricted to the literate members of the forums. The illiterates started lower but gained more than the literates; in fact, the illiterate forum members ended up considerably higher than literate non-forum members. Another encouraging finding was that those from the poorest classes, including the group who used to be called "untouchables," also made impressive gains.

Each forum took a number of decisions for action, which were reported back to the radio station. For example, Chuye forum, in Kolhapur district, reported:

Chuye forum in Kolhapur district

1 March 1956: Will add fruit to diet.

5 March 1956: Decided to run more adult literacy classes and special classes for women; also decided to take a training camp of *tarun mandal* (youth organization).

8 March 1956: Decided not to kill wild animals that destroy rats; will use rat poison; if need be take collective action.

11 March 1956: Will try to introduce better poultry; will vaccinate poultry.

22 March 1956: Decided to dig a well by voluntary labour, and ask government for help in this.

25 March 1956: Will start multi-purpose co-operative society and sell produce through that society.

29 March 1956: Will try their best to open a *balwadi*.

1 April 1956: Decided to dig more compost pits and to make an experiment in Japanese paddy cultivation.

There is no authenticated record of how many "decisions to act" really resulted in action. However, the investigators report that they saw many action projects that had grown out of the forums, and pictures of many of these action projects exist in the files.

Asked for their general impressions of the forums, the participants were overwhelmingly in favor, as was almost everyone else who saw or had some part in them. There was general agreement that the opportunity to take part in such forums should be extended to as many as possible of the 560,000 villages in India.

From Pilot Project to National Program

However, it was three years before India decided to make the forum a national program. There was some activity between the end of the pilot project in 1956 and the decision to expand it in 1959, but only 259 forums were operating in all of India by the end of that period. The delay in coming to a decision and the experience in trying to expand the forums nationally is a classic case of the special problems involved in expanding a pilot project.

Expansion was not provided for in the design of the pilot project; it had to be planned and support for it gathered afterward, and that meant a considerable delay. Once expansion was decided on, the forums did not develop as fast as expected. The third five-year plan, beginning in April 1961, provided for the organization of 25,000 forums, but by the end of 1965 only 12,000 were in existence.

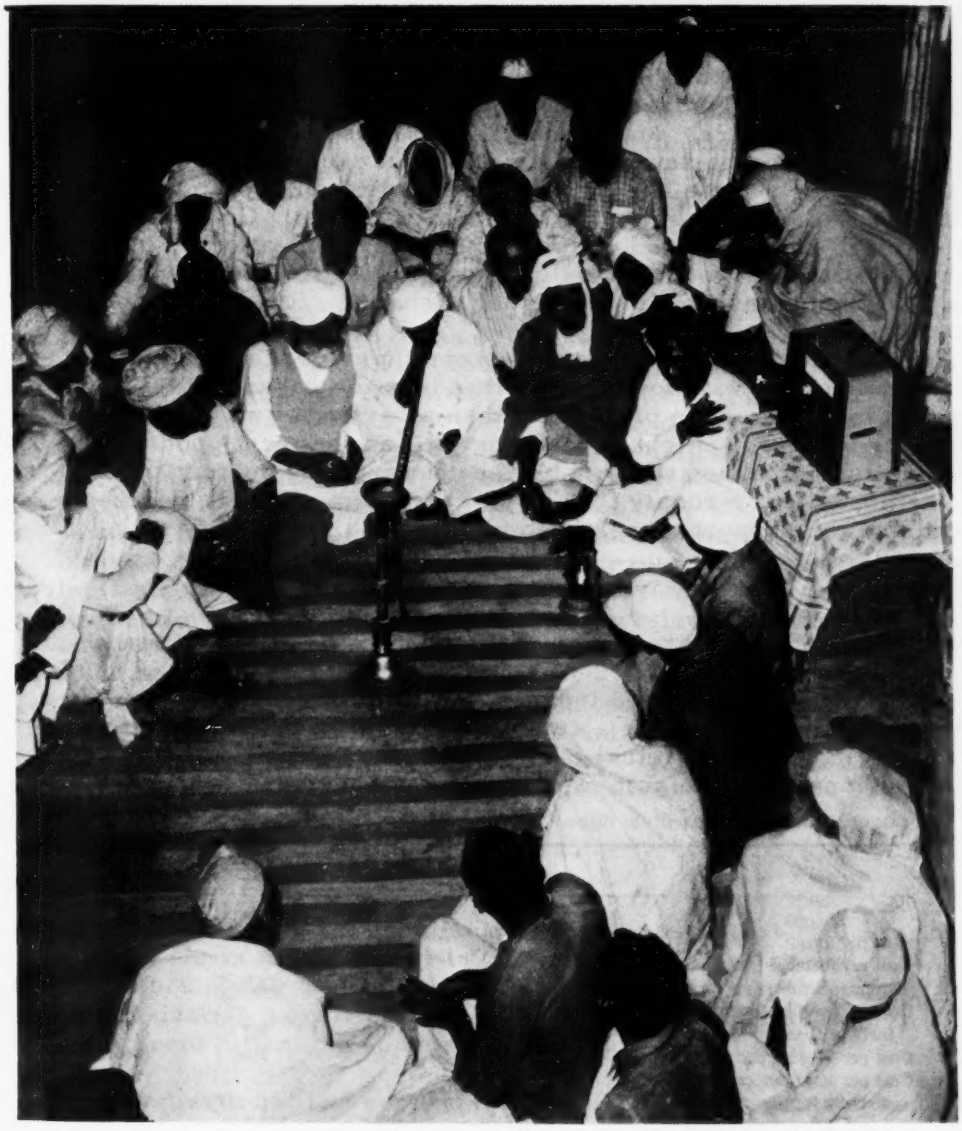
A careful government study of the forums in 1964 indicated that only about half the members of a forum attend a given meeting. Despite generally favorable comments from villagers, members do not seem to participate in discussion nearly as much as those of the Poona experiment did. It is clear that some action does result; every evaluator is able to name a number of significant community development results that have come out of the forums. But reported action, averaging two projects a year, does not match the Poona record. This should not be interpreted to mean that the radio forums have failed in India. All evaluations have confirmed their potential. Thousands of farm and community projects have come into being because of them.

It is not surprising that there has been some disappointment with the record of the forums after the Poona success. The question is whether the forum itself is a less potent tool than had been thought, or whether it is being used and supported less well than it should be.

Why Forums Fail

There seems to be a close relationship between a rapid growth rate and the amount of field support given the forums. For example, Maharashtra, with over 2,500 forums, has three full-time regional organizers, trains its social education organizers in running rural forums, and maintains the interest of its village level workers in forums. Moreover, it has an excellent field organization for

maintaining sets; a village council pays 60 rupees a year, and in turn receives continuing maintenance and replacement of batteries. The state has been careful to pay a small honorarium to the conveners of forums, and it furnishes printed registers and forms for reports of meetings. Drawing on its Poona experience, Maharashtra makes sure that not too many forums are started at once, and expands the number only when supporting field staff is available.



(photo: Press Information Bureau, Government of India)

Bihar, on the other hand, has only about 470 forums, of which a number are believed to be inactive. It has had only one chief organizer, who until recently worked only part-time on the forums. Many of its social education officers have been given additional, unrelated duties and have not been trained in organizing or supervising forums. The maintenance system has been very weak. Conveners are expected to work and report voluntarily. There has been no printed material to supplement the discussion.

No state in India has been able to afford as much field support for its forums as the Poona project had—a full-time organizer for each district, a chief organizer concerned with five districts, and some part-time organizers. Maharashtra and Orissa have regional organizers, each covering several districts. But even this compromise is insufficient for a state like Uttar Pradesh, with 52 districts, each containing an average of nearly two million people. Given the shortage of funds and personnel, it might be better and easier to begin with one district at a time, assign an organizer to it for a year or two, and then transfer him to another district.

Although not supported by any systematic evidence, the Indians most experienced with forums feel that in many cases a limited forum life might be more productive than an extended one. A forum that lasts two years might have accomplished the most good for its community and passed through its most interesting period; unless the members feel strongly to the contrary, it might well be discontinued and the support transferred elsewhere.

A Word About Costs

It is now too late to reconstruct the economics of the Poona forums, which were, in any event, experimental. On the other hand, it is clear that the expanded Indian program is underfinanced. The following tables for funding a substantial rural radio project, therefore, are not based on actual costs but, rather, on assumptions that seem reasonable to the author and his Indian advisers:

TABLE Total costs per unit (in rupees)

	First year (500 forums)	Second year (1,000 forums)	Third year (1,500 forums)	Fourth year (2,000 forums)
Total costs	256 850	398 000	548 950	689 900
Cost per forum	513.7	398	366	345
Cost per member (assuming twenty members per forum)	25.7	19.9	18.3	17.3
Cost per meeting (assuming forty per year)	12.8	10.0	9.2	8.7
Cost per meeting per member	0.64	0.50	0.46	0.44
Cost per action project put into effect by forum:				
if two per year per forum	256.9	199.0	183.0	172.5
if ten per year per forum	51.4	39.8	36.6	34.5

TABLE Total costs (in rupees)

	First year (500 forums)	Second year (1,000 forums)	Third year (1,500 forums)	Fourth year (2,000 forums)
Capital charges				
Receiving sets—depreciation	7 500	15 000	22 500	30 000
Recorders and miscellaneous items—depreciation	1 000	1 500	2 000	2 500
Total	*8 500*	*16 500*	*24 500*	*32 500*
Operating costs				
Field personnel	143 000	228 000	313 000	398 000
Training	27 450	30 100	42 550	45 000
Meetings	10 000	20 000	30 000	40 000
Radio programmes	18 000	18 000	18 000	18 000
Printed materials	6 000	9 000	12 000	15 000
Travel	11 400	11 400	11 400	11 400
Set maintenance	32 500	65 000	97 500	130 000
Total	*248 350*	*381 500*	*524 450*	*657 400*
Total, capital charges and operating costs	256 850	398 000	548 950	689 900

The cumulative cost of organizing 2,000 forums and operating the project for four years is, thus, about $379,000, excluding depreciation [calculated at the pre-devaluation rate of $1 = 4.75 rupees]; less than half of this need be new money, since we assume that village workers and radio receivers already exist. The total cost amounts to $.09 to $.12 per week per forum member. This does not seem an exorbitant price for maintaining weekly contact with a village leader; for being able to focus his attention on one of the urgent problems of development; for bringing him expert advice on this problem; and for enabling him to make a decision for community development and perhaps to translate that decision into action.

Economies of scale are not so great as with some other ways of using new media (for example, classroom teaching via radio or TV), but they are nevertheless substantial. If only 250 are organized, the estimated cost is just under $700 per forum. Costs fall sharply as the number climbs to 1,000, and then level off at about $350 per forum.

Lessons of the Indian Experience

The basic lesson of the long Indian experience is that radio rural forums will not in most cases run themselves. They are indeed a potent and promising tool of national and community development, but if inadequately supported they will yield disappointing results. Adequate preparation and support in the field necessitates:

1. Organizational and supervisory staff—a chief organizer and enough district or regional organizers—supplied with transport.

2. Commitment and involvement on the part of the development field staff at every level—block development officers or their equivalents, the village level workers, and the technical field specialists in agriculture, health, and other subjects taken up in the forums.

3. Training for every key officer directly concerned—the district organizers, the block officers, the village level development workers, and the chairmen and conveners of the forums. The latter two in particular need training in conducting discussions. The village and block level workers need to study the working of forums in broad terms, and the organizers must be trained in every aspect of forum operation, as well as in village structure and especially in ways to select villages and members and to manage the dynamics of introducing new village institutions.

4. Radio programs fitted to local needs and interests. This localization implies not only continuing feedback from forums to the radio station, but also a considerable amount of travel and recording in the villages by the program staff, opportunities for local people to participate in programs, and close and prompt attention to questions and requests from the villages.

5. Arrangements to maintain radio receivers in working order. Maintaining uninterrupted service will require a field technical staff, transport, spare parts, and some extra receivers.

6. Resources to follow up decisions for action. In order to translate decisions into action there will have to be in some cases demonstrations of new techniques, in others short training courses, in still others printed materials, and in every case a supply of whatever materials are required for the action. Nothing is more discouraging for villagers than to decide to introduce fertilizer and then be unable to obtain it, or to decide to try a supposedly more efficient method of paddy culture and then not be able to get instruction in the new method.

More is now known about the conditions under which a village is likely to have a productive forum. The most general requirements are: a compact community, with about the same kinds of agricultural problems; a community with as little internal conflict as possible; and a community outside the shadow of a great city. (Villages within 8 or 10 miles of a metropolis tend to be suburban rather than rural.) Membership should be sufficiently diversified, so that the forums do not become clubs for the people who need them least. Special programs and separate forums need to be arranged for the women.

The recent advice of Indian experts on the forum is that organizers should think twice before using the political head of the village as a chairman or the secretary of a village council as a convener, and

also that village teachers and development workers should be used sparingly as conveners. The principle is that if these workers carry the responsibility, the forum will not be useful in extending democratic participation beyond its present levels. On the other hand, at least one report gave credit for the success of its best forums to the efforts of development workers as forum officers.

Finally, Indian officials and experts well acquainted with the forums have come to believe that a pilot project is a good investment as a first step for any relatively compact district or other political unit planning large-scale development of such an activity as a forum. Maharashtra State clearly profited from having the Poona pilot project. Other states would also have profited from a pilot project; they might well have discovered in advance some of their own special problems, and been able to plan for them.

The task of expanding a small and successful project is usually underestimated. As a result, the elements that made the pilot project a success tend to be weakened. The pilot project usually has highly motivated leadership, and the leader succeeds in infusing his staff with much of his own interest. The expanded program tends to become routine. Furthermore, the sponsors of the program tend to take the expansion too casually and try to save too much money and manpower on it. Theoretically, unit costs should be lower (though the total cost will rise) and the expanded system should take proportionally less manpower. This is probably so, but the requirement tends to be underestimated, and the program is thought to take less support than it really needs. The pilot project, which is being closely watched, is given enough staff and enough material to do what needs doing. The needs of the expanded project are more easily ignored. Once the pilot project has proved the plan's feasibility, people expect an enlarged program to run pretty much by itself. Training is often neglected, staff is too small, budgets are limited. The importance of the task is not communicated to the person doing it. With less interest, fewer resources, less care, it is not surprising that the program often falls below its original promise.

Perhaps one of the most important lessons to be learned from this experience is that the task of expanding from a pilot project to a state-wide or nation-wide activity is itself a challenge in development planning. It will introduce new problems not encountered in the pilot project, and will require a major effort of management and leadership.

[Adapted from "Ten Years of the Radio Rural Forum in India," New Educational Media in Action, op. cit., Vol. I, pp. 107-134.]

NIGER: EXPERIMENTING WITH AUDIO-VISUALS

Robert Lefranc

[Niger's experiment with combining radio and film-strip projection has not yet progressed very far, but the technique has a glint of potential value.]

Although it has by no means taken full advantage of their potential, Niger is experimenting with use of radio and film-strip projection in its literacy campaign, along with more standard methods. The two are sometimes used individually, but an effort is being made to use them in combination—known as "radiovision"—for increased effectiveness. In theory, radiovision will offset the scarcity of qualified teachers and organizers.

The literacy campaign dates from 1961. It is based on the "Solères method"; this method of teaching French to adults uses numerous illustrations originally intended for printed presentation but adaptable to film-strips. By 1964/65, the campaign included 121 beginners' centers, 64 advanced centers, and 12 city centers—a total of 197, involving over 11,000 adults. Courses are offered in both French and the vernacular languages, but French is much the more popular since, even in the villages, a mastery of French offers the only means of achieving upward mobility. In one village, for example, only five students came to a course in the vernacular while 45 were attracted to the French course.

The basic textbook for the beginning class, Savoir pour mieux vivre, includes material on geography,

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hygiene, and arithmetic as well as literary passages and writing exercises. Advanced classes use small booklets on practical matters relating to health, culture, civic life, etc. They also get a newspaper, The Literacy Courier, which is very popular in the villages among new literates. By the third year, the students use French textbooks and a regular newspaper. Twenty-one film-strips of twelve to fifteen frames each show situations and characters well known to the students. The radio transmissions, broadcast from 9 to 11 a.m. on Thursdays, are produced partly by Radio Niger and partly by the literacy service itself.

A literacy center's usual schedule is three sessions of an hour and a half a week; for half of the last session, the instructor uses radiovision. Greater use of radio will be possible when additional scheduled transmissions can be provided by Radio Niger. The courses run for five months—January-June—coinciding with the bad weather when work in the fields is impossible. Evaluation has indicated that this seven-month break between courses is too long to allow new literates to retain and consolidate what they have learned, but the authorities are hoping to maintain villagers' interest by means of simple, locally-produced news bulletins that write up important events in the region and carry development advice and information.

The authorities have been careful to minimize potential opposition to the literacy program by involving the village power structure in the courses. For example, the village chief usually serves as president of the center, although he rarely attends the sessions. Village teachers and schoolmasters are usually employed to do the teaching. And the political hierarchy is pressed into service. The party has contributed up to half the fees paid to teachers, and it has been found that villages where the party is strong contribute more willingly than those where it is weak.

The results of the literacy program as a whole are encouraging. An average of 50 percent have successfully finished the courses, and the achievements go well beyond a narrowly defined literacy per se. For example, the medical authorities of the Zinder area have noted that the number of deaths from meningitis and measles has declined greatly in villages where the literacy campaign has been conducted. In the Madaoua region, the number of rural parents bringing their children to the dispensary has more than doubled, and a more active participation in public meetings in the village is also noted.

The Promise of Radiovision

The part played by radiovision in Niger's campaign against adult illiteracy is clearly relatively small. In fact, radiovision is hardly

integrated in the effort as a whole. Most of the time it is the voice of the teacher which supplements and supports the visual image projected rather than a radio program conceived in conjunction with the film-strip. Moreover, the audio-visual aspect of the instruction is still superficial, if not optional.

The reasons for this are many. For one thing, all of the text materials intended for teaching spoken and written French have been produced in France, with the exception of The Literacy Courier. While the technical quality of the materials thus produced is undoubtedly superior, they suffer from lack of relation to life in Niger. Furthermore, the start of the 1965/66 program came near to cancellation solely because of a delay in the delivery of text materials.

There has also been some trouble with the equipment. In many cases, the plywood cabinets of the radio sets have had to be replaced after the rainy season. (The literacy service would like one of the international organizations to design a simpler type of set, perhaps adapted for one wave-length, that is constructed for use in tropical Africa.) While the kerosene-operated slide projectors have performed satisfactorily, the literacy service wants to try others. The slates used by the students proved unsatisfactory, and too many of the ball-point pens that were supplied were old and dried out.

It is a pity that radiovision is not better integrated into the literacy program. Its systematic insertion into the literacy program would undoubtedly offer certain advantages. It would provide a guiding work rhythm for both students and inexperienced teachers. It would make certain that students hear French well spoken. It would make it easier to use ordinary monitors for class supervision instead of the qualified teachers who are so scarce in the country. And it would help to fix, by means of the visual image, word-meaning associations in the minds of the pupils.

But if the program is to make itself felt, the following need to be done:

1. Improvement of logistic support, especially with regard to broadcasting coverage and the transportation of supporting material to the villages.

2. Production of film slides and radio programs at Niamey, even if manufacture must continue to be done in France. Radio programs must be better adapted not only to adult students but also to the various regional and tribal groups of Niger.

3. Strict technical and pedagogical coordination of film-strips with radio programs, in their conception and in the transmission and follow-up.

4. Establishment of a more effective feedback system.

5. Better training for the local instructors using the system.

6. More systematic coordination at both national and local levels between the literacy effort and other development activities, as well as much greater availability of reading material for new literates, both in the vernaculars and in French.

[Adapted from "Educational Television in Niger," New Educational Media in Action, op. cit., Vol. III, pp. 43-57.]

SATELLITES FOR EDUCATION

Wilbur Schramm

[Using communications satellite technology for educational purposes is probably justified for some countries, under some conditions, at some stage of development. Its use raises problems of scale and educational philosophy, however.]

No use of modern communication has so interested the planners as the possibility of using satellites in support of education. And because television and radio have played such a large part in all such schemes, the question has inevitably been raised whether a communication satellite could not do better, and perhaps more cheaply, over a far greater area, what radio and television have done in limited areas.

A point-to-point satellite, of course, could not contribute much to an operation of this kind. A distribution satellite, at least, is required, and, if possible, a satellite that would have some capability for both direct broadcasting and distribution. For example, preliminary cost studies indicate that for a country like India—where television exists in only one city, where telecommunication is not well developed, and where perhaps one-fourth of the population could be reached by television stations in the large cities—the least expensive way of bringing television to most of the country would be a combination of rebroadcast and direct broadcasting from a satellite.

If a distribution satellite could be used in a developing country, it would, in effect, take the place of microwave links or long lines to local stations, and the country could, for the time being, forgo that

A second article by Dr. Schramm
appears on p. 66.

expenditure. If the whole country could be served by direct broadcast, it would be possible to leap over the stage of building local stations.

A considerable part of the ground cost, however, could not be avoided in any case. Receiving sets and antennae would be needed. Electric power would have to be available. There would have to be provision for maintenance in the villages as well as the cities, and a number of electronic components and units (including sets) would either have to be manufactured or purchased with foreign exchange. In Samoa, for example, it was found that new schools had to be built before television could be effectively introduced. For any large country, the cost of the ground segment would probably be considerably more than that of the space segment. And the annual operation of the ground segment would be very much more than that of the space system. It would include programming, maintenance, the very extensive arrangements for cooperation and liaison between schools and program centers, and the materials that would have to accompany the broadcast instruction.

Just as television is a mass medium and has to be used in a large way if unit costs are to be acceptable, so a communication satellite is a very large telecommunication system which has to be used to serve a great area lest the unit costs be out of reach. "A little" use of a satellite system for education and economic development is not a reasonable policy for a developing country.

This is not to say that such an investment is not justified. Rather, the point we are trying to suggest is that it is probably justified for some countries, under some conditions, at some stage of development.

One touchstone is size. For unit costs to be favorable, compared to other ways of delivering a signal, the country must be very large—perhaps a million square miles—or the satellite must be used to serve a cooperating group of countries. For educational use of a satellite, however, this raises the question of local needs and patterns of education.

One of the essences of education is localness—individual differences among students and consequently different needs for instruction; local class schedules and local curricular patterns; differing content of courses based on local interests, surroundings, and occupational goals; differences in standards of accomplishment between schools or regions; different customs; sometimes different languages. The same problem carries over to adult education and development information. For example, dry wheat farmers will be very little interested in the kind of advice to be given wet rice farmers; the fishermen of Kerala would gain little from instructions broadcast to Rajasthan about the diseases of camels.

Therefore, any country or group of countries thinking of a satellite for educational uses must ask what material can profitably be broadcast to the entire region served by the satellite, or what division of satellite time or of satellite channels (if it has more than one) would meet the different needs of different parts of the region.

Where television has been used for education, it has been found that its effectiveness depends greatly on the kind of activity that is stimulated at the receiving end. A disgruntled classroom teacher, or one who is not cooperating with the studio teacher, can easily cancel out the advantage of putting an expert teacher on television.

This kind of problem will be even more demanding when a satellite is put into the communication chain. It is harder to bring all teachers into the planning, to keep up liaison and feedback, and to pitch the broadcast at a level that will stimulate all classrooms. At the very least, therefore, educational use of a satellite would require very careful and skillful administrative planning, a considerable effort to assist the classroom teacher to learn her new role, and a large staff of field workers, supervisors, and counsellors to maintain contact between central administration and programming, and the schools and classrooms. In a country large enough to use a satellite expeditiously—that is to say, a country like India, Indonesia, or Brazil—that field staff would probably number in the thousands. For adult education the broadcasts would have to be combined with a field staff and organization even larger—perhaps something of the order of India's 35,000 village level workers. If a group of countries uses a satellite for education, they will almost certainly need an international organization to plan and coordinate programs and provide for liaison with users.

A country that is considering the use of a satellite for education must neither be frightened away by difficulties like these nor carried away by the heady prospects. Rather, it must ask some very hard questions about whether its educational problems are better solved in the future by a satellite system or by some other solution—for example, ground-based television, or an expanded and improved program of teacher training. And if the satellite looks sufficiently attractive, then the country must ask what steps it must take to prepare for the satellite system, and whether it is prepared to take those steps at once or to schedule them over a period of years.

[Excerpted from "Problems of Specific Uses," Reports and Papers on Mass Communication, No. 53: Communication Satellites for Education, Science and Culture. Paris: UNESCO, 1968, pp. 18-19.]

THE FERTILIZER INDUSTRY

FERTILIZERS: A BASIC PRIMER

J. Chanmugam

[Some basic information is necessary to enable the non-technical reader to understand the terms used in discussions of the fertilizer industry. This article includes a description of the most important fertilizers, their physical properties, the processing methods used, and costs.]

The primary function of fertilizers is to provide necessary plant nutrients for growing crops. High natural soil fertility is a rather rare phenomenon anywhere in the world, and few soils can be cropped economically for more than a few decades continuously without requiring supplementation with essential plant nutrients. In any permanent agricultural activity, the maintenance, let alone improvement, of soil fertility can only be accomplished by returning to the soil at least those quantities of plant nutrients which have been removed by cropping, leaching, and erosion. The appropriate use of fertilizer—along with other inputs—is obviously essential to achieve the high yields required by current population increases.

The advantages derived from fertilizer applications are similar throughout the world; only the degree of benefit changes from area to area, depending on such factors as soil conditions, climate, educational level of the farmer, farm management practices, etc. From the point of view of the farmer, however, the use of fertilizer is only valuable if it produces a profit—that is, if the value of

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increased crop yield is greater than the cost of the fertilizer (including application) plus the cost of harvesting and storing the additional crop. In general, the greater the profit obtained by fertilizer application, the more fertilizer will be used per unit of cropland. Thus, average applications on valuable fruit, vegetable, and tobacco crops are often two or three times those on field crops.

Plant Nutrients: Demand and Supply

Some fifteen elements are known to be essential to plants. The three most often seriously lacking are nitrogen (commonly designated by the letter N), phosphorous (P_2O_5), and potassium (K_2O). Singly or in combinations, these three are the major components of chemical fertilizers.

Estimated fertilizer productive capacities, 1965 [1]

[Thousand metric tons]

Area	N	P_2O_5	K_2O	Total
Asian Subcontinent	1,299	421	240	1,960
(India)	(534)	(245)	(—)	(779)
Africa	347	669	----------	1,016
Latin America	1,063	437	21	1,521
(Brazil)	(31)	(74)	(—)	(105)
Total	2,709	1,527	261	4,497

[1] Includes only fertilizer production units that were known to be operating as of July 1, 1965, according to McCune et al. (2)

Nitrogen is agronomically much the most important of the three for many complex reasons, the purely technical aspects of which need not be discussed here. Nitrogen is deficient in most soils and does not tend to accumulate from applications. When it is not present in sufficient quantities, crops often do not reach their normal size, weight, color, water content, and succulence. Maintaining an adequate supply in the soil is one of the most troublesome problems in agriculture. Recent studies have shown that, even though more nitrogenous fertilizer is being used than ever before, twice as much nitrogen is actually being removed by crops as is being added to soils. The amount of nitrogen required by the soil varies from region to region and crop to crop, but in all cases increases in yields and resultant economic gains are great.

Phosphorous tends to hasten maturity of plants, influences proper cell division, develops good root systems, causes formation of fat and albumin, and generally gives strength to the plant. Its benefits are minimized, however, unless the nitrogen content of the soil is first raised to required levels.

Potassium influences the development of the woody parts of stems and pulp of fruits. It affects the plant's natural oxidizing and

reducing processes, protein synthesis, and development of chlorophyll. Adequate potassic content enables plants to resist a variety of diseases, as well as ill effects due to over-application of other nutrients.

The chemical fertilizer industry to supply these nutrients is growing rapidly, both in terms of exports from industrialized nations and in terms of manufacture in the developing world. It has been estimated that the developing countries alone must increase their use of chemical fertilizers from 6 million metric tons in 1966 to 40 million by 1985 merely to keep agricultural production abreast of population growth. Production of this magnitude will not be easy to achieve, since the fertilizer industry is highly capital intensive and requires much skilled manpower.

The Science Advisory Committee of the United States [see The World Food Problem, Vol. II, p. 382] estimates that a capital investment of $500 per metric ton of plant nutrient capacity is necessary for mining or manufacturing and distribution of fertilizer in the developing nations. This $500 includes warehousing, railroad cars or equivalent, vehicles, distribution outlets, and working capital, as well as actual mines and plants, but it makes no allowance for any infrastructure—e.g., port facilities, roads, or railroads—which might be required.

Fertilizer needed to increase agricultural production on acreage now under cultivation in Asia,[1] Africa, and Latin America by the percentages indicated

Percent increase in agricultural production	Tonnage of plant nutrients needed (millions of metric tons)	Percent increase in fertilizer use	Capital needed	Total annual cost
			(Millions of United States dollars)	
	[2] 6			1,300
10	11	80	2,500	2,400
20	16	165	5,000	3,500
30	21	257	7,500	4,600
40	26	345	10,000	5,700
50	32	440	13,000	7,000
60	38	535	16,000	8,400
70	46	645	20,000	10,100
80	53	765	23,500	11,600
90	60	885	27,000	13,200
100	67	1,000	30,500	14,700

[1] Except Mainland China and Japan.
[2] Actual consumption in 1966.

The Committee notes, however, that the impressive capital requirements will be much easier to obtain than the necessary manpower. About three skilled and five unskilled people are required for every thousand tons of plant nutrients produced and distributed

per year. Approximately half of the skilled personnel would need to be college graduates or equivalent, while the remainder would require on-the-job technical training after secondary school. This suggests that 50,000 college graduates would be needed by 1985 in the fertilizer and associated industries in the less developed world if the target of 40 million tons were to be reached.

Essentially, the fertilizer industry is engaged in converting plant nutrients from their elemental state to a form which can be taken in by the growing plant. The three major nutrients cannot be taken in directly; instead, plants require the nutrient in soluble form in an aequeous medium—one reason why adequate availability of water is supremely important.

Once manufactured, fertilizer is graded according to its percentage content of nitrogen, phosphate, and potash, in that order. For example, a 20-16-18 fertilizer contains 20% N, 16% P_2O_5, and 18% K_2O. The remaining 46 percent is "filler" of inert material. It is important in this connection to differentiate between "mixed" fertilizers, where two or three mono-elemental fertilizers are mixed in a purely mechanical operation, and "complex fertilizers," which result from a chemical synthesis whereby the nutritional elements are "born" within the product. Complex fertilizers are considered definitely superior.

Recent agricultural practices have tended to favor the concentrated, high-analysis fertilizer grades—urea (45% N), ammonium nitrate (33% N), and high-grade complex fertilizers (14-14-14, 20-20-0, 12-24-12, 10-20-20, etc.). These have distinctly lower transportation, handling, storage, and application costs per unit of fertilizer element. As a result, despite a sometimes higher manufacturing cost, they can be supplied to farmers at lower unit costs than the low-analysis products.

Nitrogenous Fertilizers

All nitrogenous fertilizer manufacture ultimately involves the capture of nitrogen from air (which is about 80% N) and its conversion into an assimilable and soluble form. The commonest forms of soluble nitrogenous compounds are ammonia and its derivates (e.g., ammonium sulphate, ammonium nitrate, ammonium chloride), nitrates such as calcium nitrate or sodium nitrate, and urea. The proportion of nitrogen in any of these soluble compounds is what is finally important in a nitrogenous fertilizer. In addition, an increasingly high proportion of nitrogen is applied to the soil in complex or mixed fertilizers. The following are the most commonly used nitrogenous fertilizers:

Ammonium sulphate (20% N) was the most important nitrogenous fertilizer before World War II and is perhaps the most popular general-purpose fertilizer today. It is the principal form of nitrogen exported to underdeveloped countries, especially in Asia. Currently, however, other nitrogenous fertilizers show a higher rate of growth, both in production and use. Most of the ammonium sulphate that is commercially traded today is obtained as a by-product from coal and coke ovens.

Ammonium nitrate (33% N) is an inorganic salt, very soluble in water. It is 100 percent available to the plant and has both the quick-acting characteristic of nitrate and the slower action of ammoniacal nitrogen. In general, soil acceptance patterns and agronomical average values are good for all crops. Ammonium nitrate gives consistently superior results in fertilizing low nutrient and dormant soils. It is especially suited to pastures, cotton, and corn.

A feature of the postwar growth of fertilizer nitrogen trade has been the increasing part played by ammonium nitrate alone or diluted with powdered limestone or lime* (usually to 21% N, about the same as ammonium sulphate). These materials together now account for nearly 25 percent of total fertilizer trade, largely as a result of the sharp rise in ammonium nitrate capacity in all the major producing countries, especially the United States.

Capital investment and production costs per unit of nitrogen are comparatively low for ammonium nitrate. The manufacturing process involved is to first oxidize ammonia with air in the presence of a catalyst to nitric acid. The nitric acid is then neutralized with additional ammonia to yield ammonium nitrate. No additional raw materials are required. Because of its high N content, ammonium nitrate effects economies where transport over long distances is involved. It is generally manufactured as a coated pellet, which is easily stored and handled, showing both chemical stability and ease of mechanical handling. Extensive tests have proved that fertilizer-grade ammonium nitrate, as such, is not an explosive. A detonator such as dynamite is required to make properly prepared ammonium nitrate explode. Production of ammonium nitrate is particularly advantageous, in terms of cost, when combined with the production of complex fertilizers.

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*Lime is used to control soil acidity, which must be kept down if fertilizer is to be effective. "An energetic program will be necessary to convince farmers to adopt good liming practices. To illustrate the magnitude of this problem, educational efforts in the United States conducted over a relatively long period of time have resulted in the use of only 50 percent of the total amount of lime actually needed." [The World Food Problem, Vol. II, p. 380.]

Urea (45% N), with the highest N concentration among solid nitrogenous fertilizers, has made the most recent major impact on international fertilizer trade. It now accounts for more than 25 percent of total export trade and is increasing its share faster than any other fertilizer material. Its suitability for agronomic conditions in Asia, high nitrogen content, and increasingly competitive price promote outlets for a rapidly expanding production capacity and promise to improve urea's position still further. The principal exporters of fertilizer-grade urea are Japan, Netherlands, Italy, the United States, and Canada. Many of the new plants throughout the developing world are also designed to produce urea.

Urea is readily soluble in water and completely available to plants. It lends itself readily to application directly as a solid or in irrigation waters. Generally, its nitrogen content is more slowly available than ammonium nitrate. It is an almost ideal fertilizer to be applied at planting, and has proved particularly suitable for tree crops, rice, and tobacco.

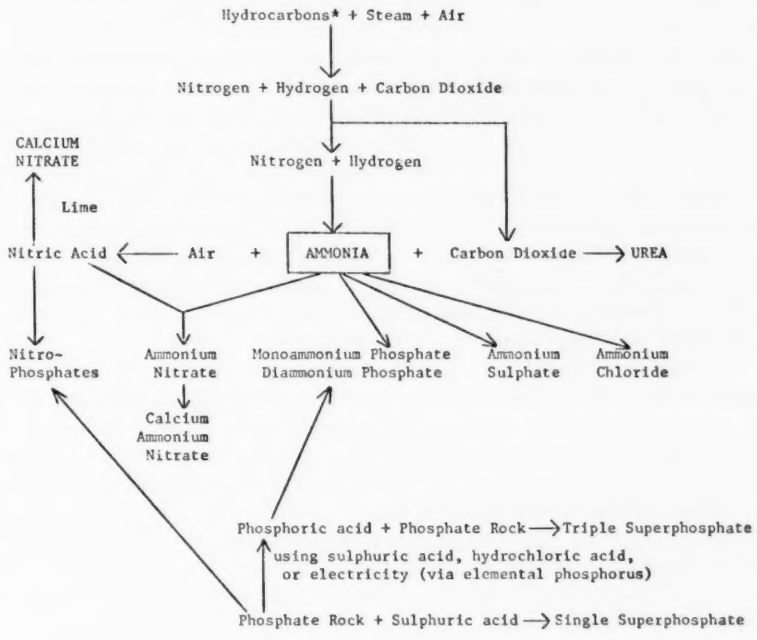
Urea is generally manufactured by passing a mixture of carbon dioxide (which is a by-product in the production of ammonia) and ammonia itself under high pressure to form ammonium carbamate. Urea is formed when the pressure is released. Because both raw materials for urea production are cheaply available from an ammonia plant, its production costs are lowest per unit of nitrogen of any major fertilizer. Its high nitrogen content results in cheapest transportation and storage costs, and when in a coated and pelleted form, it is easily handled and stored. It can be used in mixed and complex fertilizers and as a nitrogen supplement in cattle feed, as well as for direct fertilization. Eventually, an expanded urea output may be used for the manufacture of a whole range of chemical and plastic products. Although its world selling price is still high, urea is constantly gaining in importance; it probably has the greatest future potential of all the nitrogenous fertilizers.

Ammonium Phosphate. A very common form is the so-called 16-20 grade—essentially a mixture of phosphoric and sulphuric acids with ammonia. Consumption of ammonium phosphate has grown extensively during the past few years. This is primarily because it is an ideal N-P_2O_5 fertilizer, with a good agronomic value, 100 percent water soluble, good physical properties, and good mixing properties. One drawback at present is that its manufacture requires sulphur or, alternatively, sulphuric acid, since phosphoric acid must first be obtained from phosphate rock. Sulphur is in relatively short supply.

Nitrophosphate is the name given to a complex mixture of nitrates and phosphates made by neutralizing phosphate rock with nitric acid. It can be made over a wide range of compositions varying from 14%

to 33% N and 14% to 33% P_2O_5. It is used fairly extensively in Europe, and most European exports to Asia of complex fertilizers consist of nitrophosphate with added potash. Unfortunately, not all the phosphorous in nitrophosphate is in an immediately soluble form; as a result, the modern trend is to use ammonium phosphate instead.

Product Interrelationships of Nitrogen and Phosphate Fertilizers



*Hydrocarbon feedstock can be natural gas, ethane, liquefied petroleum gases (LPG), or light naphtha for the reforming process. With heavier hydrocarbon feedstocks, partial oxidation processes would have to be used, which require higher capital costs than the reforming process.

Nitrogen in complex and mixed fertilizers. Most crops respond to a balanced plant nutrient application better than they do to any single fertilizing element alone. One-sided fertilization may, in fact, have eventual negative effects. In order to satisfy these needs, high-analysis fertilizers such as 14-14-14, 12-24-12, 20-10-10 formulations and the like have been developed. These permit balanced application of the three basic fertilizing elements, even for inexperienced farmers. Such fertilizer can be manufactured in the grade best suited to the particular crop for the particular location where it is grown.

Nitrogen in such formulations will not tend to decrease ammonium nitrate and urea applications, but will often be used in conjunction with direct applications of the straight nitrogenous forms.

Phosphatic Fertilizers

Phosphate rock, averaging 30% P_2O_5 is the principal natural source of phosphorous. It is found in commercially exploitable quantities in only a few places: U.S., Morocco, Tunisia, Senegal, Jordan, U.S.S.R., and the Oceania Islands.

The major constituent of raw phosphate rock is flourapatite, an insoluble variety of calcium phosphate which must be made soluble with a suitable acid. Single (18% P_2O_5) and triple (45% P_2O_5) superphosphates—most commonly obtained by treating the phosphatic rock with sulphuric acid—are by far the most important phosphatic fertilizers. Phosphoric acid, which is also obtained by a process involving sulphuric acid, is employed in the manufacture of complexes; it usually contains 30% P_2O_5. Since sulphuric acid is so generally used, the availability of sulphur is an important factor in this branch of the fertilizer industry. Present prospects are for at least temporary shortages of sulphur and high prices.

Small-scale manufacture of soluble phosphates, though common in the past, is a relatively expensive operation. The tendency today is to build plants of at least 500 tons/day P_2O_5-capacity, calling for approximately $15 million capital investment. Production costs depend on the cost of the rock and of sulphur; in the U.S. at today's prices, production cost (including depreciation) is of the order of $70 per ton of P_2O_5.

Potash

Potassium chloride (muriate of potash) and potassium sulphate are the principal potassic fertilizer materials. They are commercially exploitable only in mineral form or by evaporation of certain brines, all of which are soluble. In most of Europe, U.S.S.R., U.S., and Canada, potash is obtained from underground mines. In Israel, and potentially in Jordan, its manufacture is based on the solar evaporation of Dead Sea brines. Ethiopia's deposits are beginning to come into production.

The facilities to exploit potash resources are necessarily large and expensive. Almost all of the new ventures and those under active consideration have a rated production capacity of a minimum of about 0.5 million tons of K_2O/year involving an investment of at least $50 million in the productive facilities. Export prices average $60-$65 per metric ton, f.o.b.

Ammonia

As has been noted, an adequate and continuous supply of ammonia is essential to the manufacture of nitrogenous and complex fertilizers. Indeed, ammonia can be used directly as fertilizer, as is common in the United States.

Ammonia is the end result of the synthesis between hydrogen and nitrogen gases. Nitrogen is obtained from air. Thus, the production of ammonia is primarily influenced by the choice of hydrogen source. Hydrogen is obtained from hydrocarbons, the most important of which are the petroleum-based products, in particular naphtha and natural gas, but also including coal, coke oven gas, lignite, etc. The choice of raw material is obviously determined by availability and costs.

Both capital and production costs are lowest for gaseous sources of hydrogen; in fact, most modern ammonia synthesis units are based on natural gas. Natural gas is considerably cheaper than liquid feedstocks. Furthermore, as a result of the discovery of vast quantities of natural gas in the Sahara and, more recently, in the Netherlands, and the fact that nearly all the gases issuing from the wells in the Middle East are presently being flared (wasted), the tendency to ship liquefied natural gas in bulk is growing very rapidly.

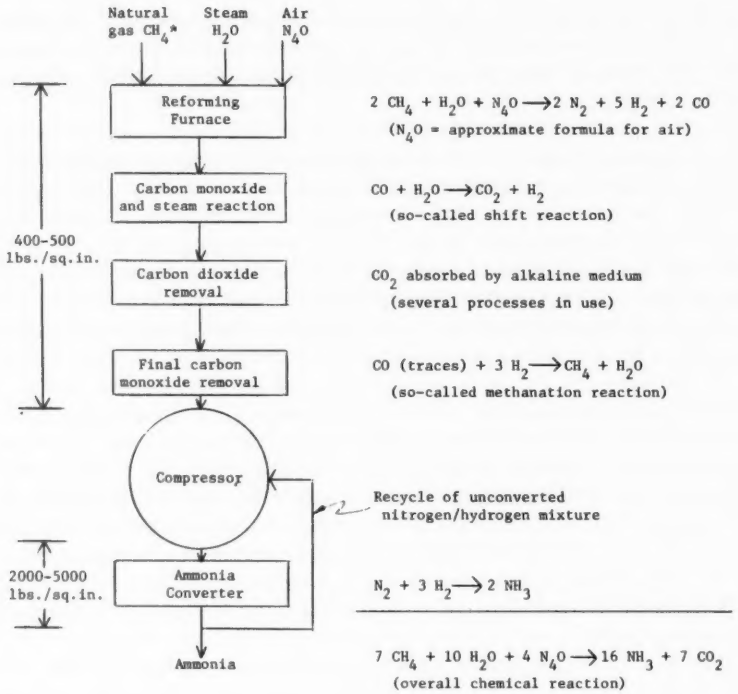
However, in many countries where gases are not available, the use of liquid petroleum feedstocks, especially naphtha, has to be considered, particularly if domestic petroleum resources are available. These feedstocks can only be obtained in the processing of crude oil. Their use is made more attractive for many countries because oil can easily be imported in bulk, especially in ocean carriers.

Both capital and production costs increase with the density of the hydrocarbon material. Solid hydrocarbons such as coal, lignite, or wood are by far the most expensive to use, although in some places their ready availability has made their use profitable.

Hydrogen can be obtained from any of these sources by one of two processing methods:

Steam reforming is the cheapest process available today. Here natural gas or naphtha, steam, and air are reacted together to yield hydrogen. As shown in the illustration, this hydrogen, together with the unreacted nitrogen from the air originally fed in, are then reacted to yield ammonia. The design of a steam reforming unit is specific to the hydrocarbon feedstock, and in this respect the process does not have much flexibility.

Process Flow Chart of Ammonia Synthesis


Natural gas CH_4*
Steam H_2O
Air N_4O
Reforming Furnace
Carbon monoxide and steam reaction
Carbon dioxide removal
Final carbon monoxide removal
400-500 lbs./sq.in.
Compressor
Recycle of unconverted nitrogen/hydrogen mixture
2000-5000 lbs./sq.in.
Ammonia Converter
Ammonia
$2\ CH_4 + H_2O + N_4O \longrightarrow 2\ N_2 + 5\ H_2 + 2\ CO$
(N_4O = approximate formula for air)
$CO + H_2O \longrightarrow CO_2 + H_2$
(so-called shift reaction)
CO_2 absorbed by alkaline medium
(several processes in use)
CO (traces) $+ 3\ H_2 \longrightarrow CH_4 + H_2O$
(so-called methanation reaction)
$N_2 + 3\ H_2 \longrightarrow 2\ NH_3$
$7\ CH_4 + 10\ H_2O + 4\ N_4O \longrightarrow 16\ NH_3 + 7\ CO_2$
(overall chemical reaction)

*Natural gas is usually largely methane, but may contain also ethane, propane, butane, higher hydrocarbons, carbon dioxide, nitrogen, hydorgen sulphide, and other gases. Ethane, liquefied petroleum gases (LPG), refinery off-gas, and light haphtha can also be used as feedstocks for the reforming process. With heavier hydrocarbons, partial oxidation processes would have to be used, which require higher capital costs than the reforming process.

Partial oxidation involves two units: 1) an air liquefaction plant where liquid air is formed and then separated into pure streams of oxygen and nitrogen, respectively, and 2) a combustion unit where the hydrocarbon and the pure oxygen stream from the air liquefaction plant are reacted together under controlled conditions. This hydrogen is then reacted with the nitrogen from the air liquefaction plant to yield ammonia. Capital costs are high. Production costs are also higher than for the steam reforming method. Very often a great deal of carbon soot is formed which requires removal. Nevertheless, partial oxidation has the advantage of a great deal of flexibility; in principle, any feedstock can be utilized, with only minor changes necessary in the operating conditions.

Costs. Since ammonia is the prime material in any nitrogeneous fertilizer plant, considerable attention is usually given to the

production cost of ammonia in a project. This naturally depends a great deal on the cost of the hydrocarbon to be used. In addition, a choice of very great significance is the size of an ammonia plant. Ammonia plants having a capacity of 600 tons ammonia/day and larger are capable of adapting the newly developed centrifugal compressors and other technological improvements which result in substantial savings in production and capital costs. It is generally true that a plant of smaller capacity than 100 tons/day is not economical; 200 tons of ammonia is about the minimum size of plant that is economically practical.

The capital investment required for a 600 tons/day unit is of the order of $15 million. If the natural gas costs 20¢ per 1,000 cubic feet (equivalent naphtha cost is about $8/ton), the production cost, including depreciation but excluding capital charges, is approximately $20/ton of ammonia. If the gas costs 5¢ per 1,000 cubic feet, the production cost is about $15/ton.

Because of the importance of ammonia as the principal intermediate in the manufacture of nitrogenous fertilizer, the tendency in recent years has been to consider very large ammonia production facilities close to the hydrocarbon source—e.g., natural gas field—where ammonia could be produced relatively very cheaply. Ammonia can then be shipped out to the fertilizer consuming regions where plants to convert the ammonia into conventional fertilizers can be installed.

[Based on material presented at various courses of the World Bank's Economic Development Institute by Dr. Chanmugam. All charts and tables are from The World Food Problem, Washington, D.C., The White House, 1967, Vol. II, pp. 382-386 and Vol. III, p. 104.]

NITROGENOUS FERTILIZERS: SOME INVESTMENT CRITERIA

O. T. W. Price

[Some criteria relating to the advisability of building fertilizer plants are easy to overlook. For example, large ammonia plants show great economies of scale only if they are used at or near capacity. The cyclical nature of the chemical construction industry offers clues as to the best timing of increases in fertilizer capacity.]

Developing countries are frequently faced with the dilemma of whether to import fertilizer products or make them locally. In the case of fertilizer N (nitrogen), they are faced with three broad choices, namely: 1) to import finished nitrogen products; 2) to import an intermediate product—ammonia—and convert this into finished products indigenously; or 3) produce ammonia and finished products indigenously and possibly import hydrocarbon feedstocks.

In deciding among these choices certain economic factors must be taken into account. The problem should first be examined as a commercial proposition. When this is done, the first fundamental comparison which has to be made is to establish whether the cost of freight and handling the imported product outweighs the difference in operating costs between a developing country and an exporting country. Costs of manufacture in a developing country will be greater than in an industrial country, because capital costs tend to be some 20 percent higher in the former and because an industrial country is more frequently able to take advantage of the economies of scale associated with ammonia and conversion plants. Costs of production per

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ton of ammonia for large plants almost half those for small plants are sometimes quoted. Thus, in many instances, a developing country will be able to import fertilizers far more cheaply than they could be produced locally.

This is particularly true because the large new ammonia plants have a high level of fixed costs, and many of the apparent economies of scale disappear if these plants are not operated at near full output. The table on page 94 shows the considerable effect of underuse of capacity on ammonia (NH_3) production costs in a large plant.

On the other hand, freight costs can vary enormously depending on the location of the fertilizer market. For example, where a finished product has to be transported not only by sea but also upcountry, and if allowance is made for handling and storage, freight costs can sometimes be very considerable, thus giving a natural geographical protection to indigenous manufacture.

On the basis of straightforward commercial criteria, it will frequently be more economical to import the finished products than to consider any form of local manufacture where the total market is only, say, 10,000-20,000 tons of nitrogen. As liquid ammonia becomes increasingly available in international trade in the future, I would suggest that even markets of between 50,000-100,000 tons of ammonia will frequently do best by importing ammonia for conversion into finished products in the local markets. Markets requiring in excess of 150,000 tons of ammonia should usually prove capable of supporting viable ammonia and conversion plants.

Most developing countries are seriously short of foreign exchange with which to purchase fertilizers or capital goods. Thus, a further criterion is the effectiveness of an investment in saving or earning foreign currency. Factors to note here are: 1) Some 40 percent or more of the capital costs of erecting a nitrogen fertilizer complex is local capital which would not have to be paid for in foreign currency, whereas all the imported finished fertilizer products would have to be paid for in foreign currency. 2) Is there a cheap supply of indigenous hydrocarbon feedstock available? For example, is naphtha available as a by-product from refining and has it no alternative use except for exports? In this case, it should probably be costed into the plant at an export f. o. b. value rather than its full market price. 3) Is there a large pool of labor, and even technical staff, available that is presently unemployed? In such an instance, the national interest might best be served by including their services at less than full cost.

EFFECT OF UNDER-USE OF CAPACITY ON NH_3 PRODUCTION COSTS OF A LARGE PLANT*

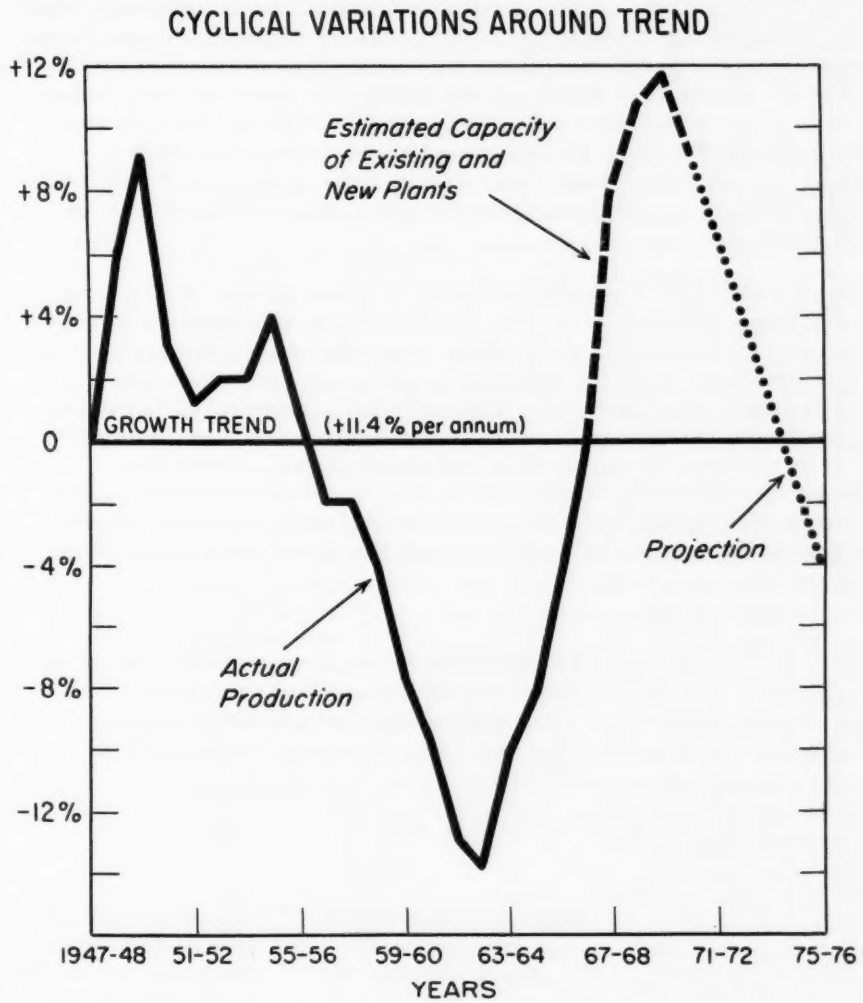
% of plant capacity employed		100%		70%		40%	
	Unit Price	consumption/ton NH_3	cost/ton NH_3	consumption/ton NH_3	cost/ton NH_3	consumption/ton NH_3	cost/ton NH_3
Naphtha: for process;	$/ton 20	0.535	$10.70	0.535	$10.70	0.535	$10.70
for heating and additional steam generation	$/ton 20	0.291	5.82	0.386	7.72	0.710	14.20
Cooling water	$/m3 0.0075	230	1.73	247	1.86	402	3.02
Electric power	$kwh 0.0125	30	0.38	38	0.48	60	0.75
Boiler feed-water	$/m3 0.20	2.25	0.45	2.37	0.48	2.47	0.50
Chemicals & catalyst			0.75		0.75		0.75
Total Variable Costs			$19.83		$21.99		$29.92
Operators	$1.75/hr. 6 men/shift		0.42		0.60		1.05
Maintenance	3%/annum		1.77		2.53		4.43
Capital cost	13.5%/annum		7.97		11.39		19.95
Total Cost Per Metric Ton NH_3			$29.99		$36.51		$55.35

* 200,000 tons/year (600 metric tons/day) NH_3 plant. One centrifugal-type steam driver compressor. Battery-limits investment $118 million, see European Chemical News, Vol. 11, No. 270, March 31, 1967.

The Advantages of Anti-Cyclical Investment

In considering investment in a developing country, some account should also be taken of the level of activity in the chemical construction industry. The following chart is an attempt to project fertilizer N production on the basis of past history. This has shown a cyclical variation around a growth trend over most of this century. At the

World Fertilizer Nitrogen Production Forecast



high point of the production cycle, the level of investment in ammonia plants has tended to be low—understandably, in view of the considerable time lag before a plant can go on stream.

The construction industry has recently passed through a marked peak of activity which has led to the industry being overstretched, completion dates delayed, and even, I suspect, tendering for new business not as competitive as it might have been. The large upsurge in capacity is expected to lead to temporary overproduction and depressed fertilizer N prices over the next three to four years; in anticipation of this, a reduction in investment activity is already occurring. It takes several years, however, to plan, construct, and bring a new fertilizer complex into full production. I would suggest that the developing countries in particular should consider anticyclical investment in fertilizer N complexes—that is, they should try to build when there is a slack in the chemical construction industry. This would have the dual advantage of 1) enabling them to have their plants built in the time promised—and at very competitive prices; and 2) it would increase their indigenous supply of fertilizer N in the mid-1970s when prices on world markets will probably be rising quite rapidly.

While these are some obvious criteria which must be taken into account in deciding whether to invest in fertilizer N plants in developing countries, it should be said, first, that the decisions of private industry and the state could be different, and, second, that when all the relevant factors are taken into account almost every investment decision relating to fertilizer N plants tends to be unique. Consequently, it is a subject on which it is impossible to generalize. Equally, there can be little doubt that it will continue to make sound economic sense to import finished or semi-finished nitrogen products into the expanding markets of many of the developing countries for years to come.

[Excerpted from a speech delivered to the Canadian Fertilizers Association Twenty-Second Annual Convention, Murray Bay, Quebec, August 24-27, 1967.]

INDIA'S CALL FOR FERTILIZERS

John Dick

[When it became evident that public sector plants could not meet all of India's tremendous need for fertilizer, the government relaxed its restrictions on private investment in the field. Investors have not responded too enthusiastically, however. This article explains why.]

From independence to the end of 1965 it was Indian government policy to view the manufacture and distribution of fertilizers as essentially a public sector activity; the capacity built or planned amounted to just under 600,000 tons nitrogen equivalent. When it became evident that the target for installed capacity at the end of 1970/71 would have to be about four times this level, it was decided to open the industry to the private sector and make fertilizer manufacture and distribution a joint public and private sector responsibility. Sights may now have to be raised to a target of 4 million tons of nitrogen by 1975.

In an attempt to attract private investment, especially from abroad, a number of incentive measures have been adopted and there has been relaxation of some important controls. Reversing long-standing policy, the Government of India is now prepared to agree to foreign majority shareholding in fertilizer manufacture and to provide assistance in finding the balancing rupee finance. A high-level government committee has been set up to deal with all negotiations concerning foreign collaboration and given responsibility for taking decisions leading to the grant of the industrial license. The committee has powers to

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expedite clearance by government departments, and to help in the removal of bottlenecks. These powers extend to clearing the procedures for the import of capital goods, the acquisition of land, and local authority planning permissions. A promise has been given that adequate supplies of naphtha will be made available to every plant requiring it as feedstock.

In addition, the price and distribution of nitrogenous fertilizers, hitherto controlled by the government, has been relaxed. New projects set up in the private sector will be free to distribute fertilizer without price control for seven years from the beginning of commercial operation, even though the government has retained an option to buy up to 30 percent of each plant's production at a "negotiated" price in order to supply fertilizer at a fair price to areas remote from the factories. And the government is committed to ensuring that extra funds will be found for rural credit in excess of those available through the cooperatives, to enable farmers to buy more fertilizer.

These relaxations and incentives have been given much publicity. Following the creation of what the Government of India deemed to be a favorable climate for the foreign investor in fertilizers, a high-powered government commission even visited the United States in mid-1966 to meet and discuss opportunities with potential collaborators. To date, however, despite expressions of interest from many established international fertilizer manufacturers, the response has been slow and disappointing. The lack of interest on the part of U. S. oil and chemical firms, in particular, is said to come from three principal factors: 1) deterioration in political stability in India following the general election and the emergence of non-Congress state governments; 2) the devaluation of the rupee, causing increases in project costs and creating additional earning requirements to provide satisfactory net returns to the investor; and 3) the general tightness of the U. S. capital market reflected in higher interest rates.

Special Difficulties

At present there are nine nitrogen fertilizer factories in production, seven in the public sector and two in the private, with a total capacity of 548,000 tons, of which 18,000 tons is in the private sector. Another eleven projects, six in the public sector, are in various stages of implementation. These have a total capacity of 1,141,000 tons nitrogen equivalent, of which 514,000 tons capacity is being built by the private sector.

It is believed that eight further schemes of collaboration are in various stages of negotiation with American, British, West German, and Japanese interests. Some, at least, of these schemes will have to be brought very quickly to completion if the 1970/71 targets are

to be achieved. If all eight are implemented, the total capacity would reach 2.9 million tons of nitrogen compared with the target of 2.4 million tons. Some special problems have a bearing on whether existing inducements to the private sector are adequate to bring these schemes to fruition.

Licensing. Most of the potential collaborators whom the Government of India is seeking to interest have either never done business in India at all, or have previous experience which is limited to export sales. Those from Western countries encounter a system of government planning and control which probably far exceeds their experience of it elsewhere. The need to get licenses and government permissions at all stages of a project is liable to be misconstrued as unnecessary interference. Arguments over trivialities usually develop into mistrust and a fear of further government intervention, even to the possibility of limitation of earnings.

Siting. Since the distribution of fertilizers has for many years been handled by the government, the foreign collaborators will have little or no knowledge of how to market them; this adds to the difficulty of evaluating alternative sites for the project. As more fertilizer plants are established, the obvious locations, easily evaluated on a theoretical basis, are taken up or pre-empted. The choice of a site, therefore, may greatly depend on the view of senior officials of the government and/or the Indian collaborator.

Competition. It is well known that a number of the existing plants of the government Fertilizer Corporation are not only inefficient and high-cost producers, but have as well to support large townships for workers, and expensive welfare and amenity schemes. The foreign investor is naturally concerned to know whether competition with such plants will be on an equitable basis, so that he can assess his chances of recouping, in profits and dividends, the rewards of efficiency and productivity.

Process. Furthermore, it is to be expected that the foreign collaborator will have quite decided ideas, based on his experience elsewhere, about the process of manufacture to be employed, the scale which would be viable, and the raw materials on which the project should be based. The World Bank and some U.S. oil companies have urged the Government of India to develop part of the fertilizer industry by basing it on imported ammonia. Those who support this view point to the inevitable shortage of naphtha in India in the next ten years, particularly if the new petrochemicals industry also develops as planned. There are important short-term advantages to be got. Ammonia could be made quickly and cheaply at the Middle East oil fields, and its transport to India presents no insuperable technical problems. The investment to be made in India would be

smaller and would put less of a strain on the Indian engineering industry, and the overall effect would probably be the speeding up of the whole program. Fertilizer would become available to the cultivator sooner.

The Government of India has tended to prefer fertilizer production based on indigenous raw materials, or at least on petroleum naphtha. They maintain that the Indian refineries can be expanded to meet future requirements of naphtha for both fertilizer and petrochemical industries, and that it is important to the economy to avoid the cost of a continuing import liability for ammonia. The sensible long-term policy may in the end have to be found in a careful phasing of the whole fertilizer program, which would result in a mixture of naphtha-based and ammonia-based plants scheduled in accordance with the likely availability of their respective raw materials.

A Choice of Attitudes

In making his assessment of the investment, the potential collaborator has the choice of two basic approaches. One view, taken by a number of American companies, is that guarantees in areas of major commercial uncertainty are needed for the life of the project; these companies look for firm assurances of at least the minimum cash flow with the very minimum of commercial risk. The other view, which the Government of India seeks to foster, lies in recognizing that there has already been a remarkable departure from old fixed and doctrinaire positions about fertilizer manufacture, and that great flexibility is now being shown. It is therefore inconceivable that the present government or a future one would introduce such repressive measures as would stifle the development of such a vital industry.

The way in which the choice of attitudes resolves itself is often influenced by the background of experience of the industry with which the potential collaborator may be associated. Some fertilizer manufacturers, who also have oil interests, may take a very jaundiced view of the prospects of earning enough without guarantees to cover the risks, compared with the prospect in other countries. The same view may not be so evident in those who have connections with other sectors of Indian industry whose history and experience have been more successful. In the end, acceptance of uncertainties over the profitability of the venture can come only from demonstration by the government that it fully understands the risks which the foreign investor will be accepting, and that it can show, preferably by precedent but also by intention, that he will be able to secure whatever level of earnings a successful venture may bring.

The Public Sector

It must be appreciated, however, that the burden of solving fertilizer problems still rests substantially with the public sector. This is paradoxical, in view of the poor record of the public sector fertilizer industry in India. Of its present potential capacity, nearly half is idle, and recent achievement with the newer plants has been far from impressive. The Nangal factory, with a capacity of 80,000 tons, has seen production rise practically to full capacity and then fall over three years to 70,000. In Sindri the rated capacity is 117,000 tons, but production for the last few years has been around 96,000. The new unit at Trombay, with a capacity of 90,000 tons, has reached barely a third of this. Investment in the public sector plants works out at a capital cost of some Rs. 3,000-4,000 per ton/year [$1 = 7.5 rupees, post-devaluation], compared with Rs. 2,000-3,000 per ton/year for the new naphtha-based plants.

The Government of India has sensibly sought to secure up-to-date technology for the new Fertilizer Corporation of India plants through collaboration with the Italians, and it is to be hoped that some past errors will now be avoided. A large modern fertilizer plant is, however, a collection of highly sophisticated pieces of machinery, and there is a danger that the search for the best in efficiency, capital cost, indigenous content, or Indian design may itself give rise to new operational difficulties.

Experience throughout the world in the commissioning of large ammonia plants shows that a high proportion encounter difficulties in starting up which can be very costly in money and in loss of product. Care needs to be exercised if these difficulties are not to be added to.

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THE CASE FOR LARGE PLANTS IN INDIA

Donald Erlenkotter and Alan S. Manne

[India's domestic market is big enough to support much larger nitrogenous fertilizer plants than the ones now being built—indeed, larger than the biggest capable of being built today. Transport factors and economies of scale make it advisable to locate large plants mainly along the coast.]

Despite a large unit's economies of scale, the plant size implications are not clear cut. Savings in investment costs from a large plant could well be offset by the transport cost advantage of smaller plants in closer proximity to their markets. Furthermore, given the gradual nature of growth in demand, large plants necessitate foreign exchange expenditures for "seeding programs" prior to their on-stream dates, or else make it necessary to construct substantial amounts of idle capacity in advance of demand. To evaluate these pros and cons in the context of the Indian fertilizer industry in the early 1970s, we have constructed the models reported here.

In principle, it ought to be possible to construct a pre-investment programming model that simultaneously covers the following choices: 1) the quantity and type of product to be shipped to each consuming region at each future point of time; 2) the size, location, and time-phasing of new manufacturing capacity; 3) the choice among raw materials for nitrogenous fertilizers—natural gas, naphtha, furnace oil, coal, and imported ammonia; 4) the choice among raw materials for phosphatic fertilizers—phosphate rock and sulphur vs. phosphate rock and nitric acid vs.

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imported phosphoric acid or elemental phosphorous; and 5) the integration of these choices with supplier industries such as petroleum refineries and the railways. We have not found such an elaborate model to be feasible at this time, however, and have instead concentrated on the second and third choices. With regional demands taken as a datum, it turned out that engineering constraints—and not the size of the Indian market—dominate the choice of plant size.

A Note on Feedstocks

We have assumed that the typical project going on stream in the early 1970s will use naphtha and furnace oil as feedstock for ammonia, an intermediate which is in turn converted into urea (high analysis, straight nitrogen). The possibility that some nitrogen might be produced as complex fertilizer does not affect our conclusions.

Through a series of side calculations, we have explored the economics of natural gas, domestic coal, and imported liquid ammonia as alternatives to naphtha and furnace oil feedstocks. We cannot include all the details here, but our conclusions are: Natural gas is the ideal low-cost feedstock for nitrogen plants. However, its availability during the early 1970s will not greatly exceed the supplies that have already been committed to major projects. As for coal, the situation appears to be the reverse of natural gas—virtually unlimited domestic availability, but high costs, both on capital and operating accounts.

The third alternative is liquid ammonia imported from natural gas-based plants in the Middle East. Ammonia importation into India has aroused not only technical but considerable political controversy. On the basis of the cost data available to us, we believe that, during the early 1970s, it will be no more expensive to produce ammonia domestically in large-scale naphtha-based plants than to import this item. Because of economies of scale, the position in India is quite different from that in smaller nations whose domestic markets could not support large ammonia facilities.

Among the technoeconomic aspects that weigh against the importation of ammonia is this: for manufacturing urea, both ammonia and carbon dioxide are required. Carbon dioxide is available as a free by-product of an integrated ammonia-urea facility, but not in the case of imported liquid ammonia. Without carbon dioxide, the nitrogenous fertilizer would have to be a lower-analysis material than urea (e.g., ammonium nitrate), and would entail higher costs for bagging plus transportation. This feature is seldom emphasized by the advocates of ammonia importation into India.

Rail Transport Charges

In considering possible locations for fertilizer plants, we must first remember that, during the early 1970s, there will be no more than eight petroleum refineries in India. Hence, there will be only eight domestic sources of naphtha and furnace oil feedstock for fertilizer plants.

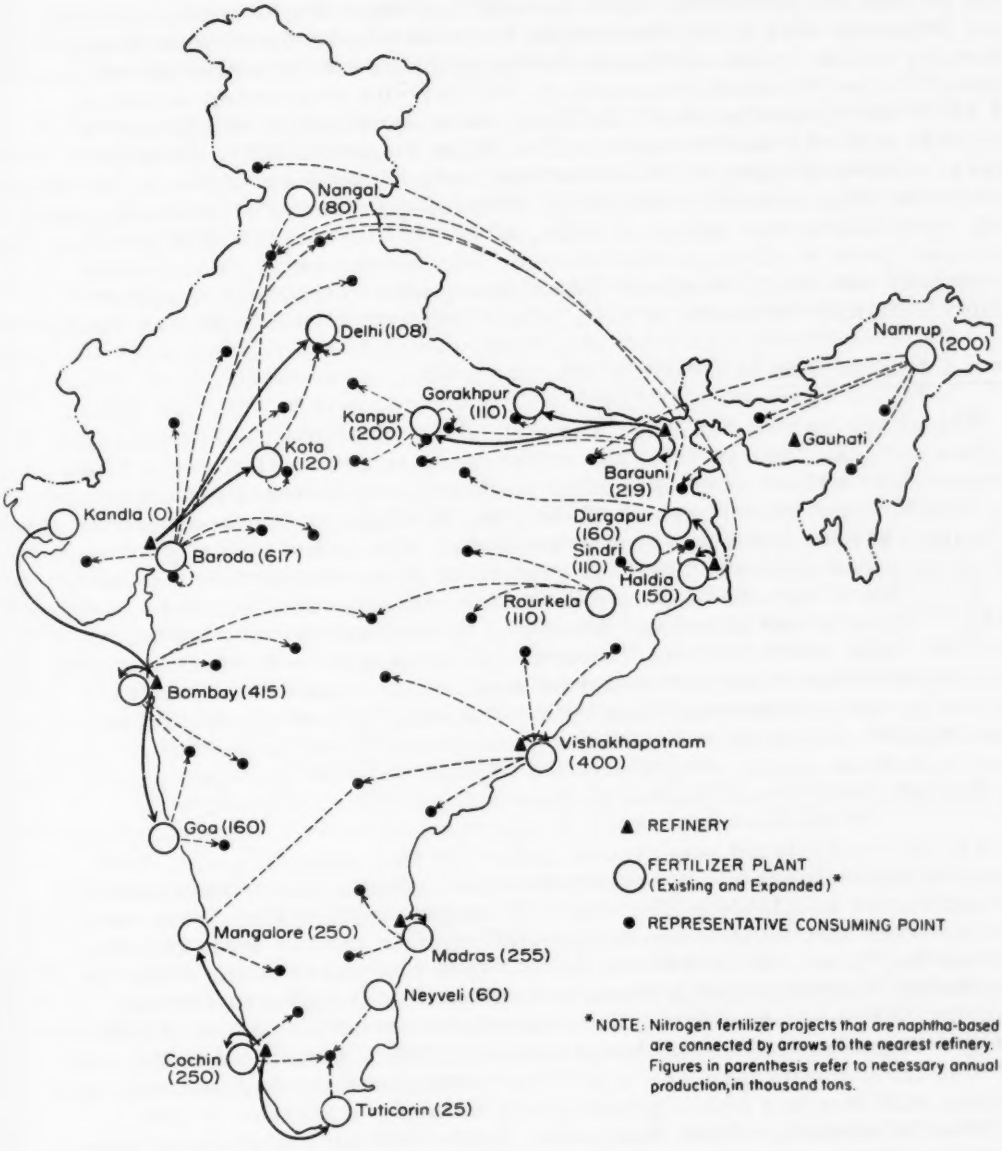
As shown in the accompanying map, three of these refineries are located inland, and are oriented toward domestic sources of crude oil: Baroda, Gauhati, and Barauni. The other five, being based on imported crude, have coastal locations: Bombay, Cochin, Madras, Vishakhapatnam, and Haldia. The map also indicates the locations of existing fertilizer projects and identifies the points we have considered as possible locations for expansions or new units during the early 1970s. Most of the candidates are coastal locations or inland refining centers. Only five are market-oriented inland sites: Durgapur, Gorakhpur, Kanpur, Delhi, and Kota.

Why so few market-oriented plant locations? Since it takes only .50 tons of naphtha and .15 tons of furnace oil to produce 1.00 ton of urea, it is tempting to conclude that the weight-gaining process should take place in the immediate vicinity of the fertilizer consumer rather than be oriented toward the source of raw materials. This reasoning, to say nothing of political pressures, leads to the common belief that the distance between producer and consumer should not exceed 500 kilometers, and that there should therefore be at least one fertilizer plant in each state of India.

Rail transport charges depend, however, not only on tonnage and distance, but also on the type of commodity shipped. Typically, India's fertilizer markets are supplied from regional distributing centers located at railheads. As it happens, despite the weight-gaining nature of urea manufacture, rail charges are lower for a ton of urea than for the petroleum products needed to produce that ton. This holds regardless of whether the shipping distance is 500, 1,000, or 1,500 kilometers. This is not unreasonable. Petroleum products transport is more expensive than an equal tonnage of solid fertilizers because both naphtha and furnace oil shipments require empty backhauls of tank cars. Moreover, naphtha represents a distinct fire hazard to the railways. Thus, assuming that rates bear any resemblance to costs, rail transport economies will continue to attract fertilizer plants toward petroleum refineries rather than toward inland markets. The possibilities of coastwise shipping would reinforce our general conclusions favoring large plants at coastal locations.

We have developed a transport cost matrix for shipments from existing and prospective plant locations to a major road or railhead

PROJECTED FERTILIZER MARKETING PATTERN, 1974



in each of 45 fertilizer consuming zones, assuming that at each location petroleum feedstock could be supplied from the nearest refinery. Our objective was to determine the location of additional fertilizer capacity which would minimize the combined cost of shipping raw materials and finished fertilizer to the various consuming points as of 1974, taking into account the location of expected production from projects already under way or with a firm commitment to be undertaken. Our calculations indicated that major capacity additions were needed at four locations: Baroda, Vishakhapatnam, Delhi, and Bombay, with additional output of 372-, 237-, 170-, and 165,000 metric tons per year of nitrogen nutrient needed respectively. Four other locations: Barauni, Madras, Gorakhpur, and Tuticorin, required minor output increments of 86-, 55-, 30-, and 25,000 tons per year.

Cost Comparisons

The above calculation may suggest likely sites for new plants, but it does not take into account the differences in production costs from various size units. For example, rather than building a plant to supply 25,000 tons of nitrogen at Tuticorin, it might be more desirable to build a larger plant at some other location which would supply these requirements until further growth in demand justified a plant at Tuticorin. To take these possibilities into account, we have selected six locations (Baroda, Bombay, Vishakhapatnam, Madras, Barauni, and Haldia) whose "natural market areas"—defined as those consuming locations which could be supplied at lowest cost from a particular plant site—would include 80 percent of India's fertilizer consumption. For these locations, expected demand growth for natural market areas ranged from a high of 103,000 tons per year for Baroda to a low of 31,700 at Barauni.

We have calculated investment costs for two sizes of plant, both based on centrifugal-compressor ammonia plants; these represent two extremes available within the 1967 engineering state-of-the-art. The smaller unit (with a capacity of 600 metric tons of ammonia per stream day; i.e., 160,000 tons of nitrogen per year) is the standard size being adopted in India at such locations as Durgapur, Cochin, Namrup, Barauni, and Goa. It is the minimum size for use of centrifugal compressors. The larger size (1,000 MT ammonia/day, or 267,000 tons of nitrogen per year) corresponds to the largest single-stream unit that had been operated successfully anywhere in the world as of the date of our analysis. Below 600 tons per day of ammonia, reciprocating compressors would be employed; these lead to significantly higher operating and capital costs per unit of output and have been eliminated from consideration here.

There are significant economies of scale in investment costs in moving from 600 to 1,000 tons per day of ammonia. Capacity

increases by two-thirds, while plant investment costs rise by about 43 percent. When there is only a small margin between costs and selling price, economies of scale can make a decisive difference in the profit-and-loss statement of an individual project.

However, these economies might be offset by the cost of temporary shipments outside a plant's natural market area and by the cost of capital tied up temporarily in excess capacity for the country as a whole. In order to determine the effects of these offsets, a further series of calculations had to be made.

In these calculations, we have set a uniform penalty for shipping fertilizer beyond the market area at Rs. 75 per ton of nitrogen in the form of urea, which would be enough to provide for rail shipment of approximately 700 kilometers beyond a plant's natural market. It was found later that a transport penalty even twice as large would not change our conclusions.

Our cost comparison assumes that demand growth increments are equal for all locations, and that plant sizes at each location will be the same. Plant construction decisions are coordinated among six potential plant locations. The sequence of capacity additions is assumed to begin with the construction of the first plant at a point in time when the demands within each natural market area have just caught up with the existing installed capacity for that area. The first plant supplies the deficits elsewhere in the country until the aggregate demand has grown sufficiently so that a second plant is required. The second unit is constructed at a new location, and the process is continued until six plants have been brought on stream, one at each of the six locations. The cycle (called a six-phase cycle) is then repeated to cover the subsequent increases in demand.

The assumptions of equal demand increments and identical plant sizes are made to simplify computations for the phasing of plants among the various areas. Differing demand increments could be studied only through a much more complex pattern of time-phasing. An asymmetrical pattern of demand increments by itself does not require different-sized plants; where demand growths were different, a standard-sized plant would simply be constructed more frequently in high demand areas than in others.

In our basic set of computations, an annual demand increment per market area of 50,000 tons per year is used—roughly the average for the six natural market areas considered. Future costs were discounted on the assumption that capital is worth 10 percent per year. The overall comparison between the two plant sizes is summarized in the accompanying table. Allowing for potential offsets to economies of scale in the form of higher transport costs and capacity built

ahead of demand, the larger plant still has a significant advantage in total discounted cost per ton—7 percent—over the smaller plant. The percentage advantage would be even greater if we were to exclude the operating costs of Rs. 350 per ton, which do not depend on the plant size decision.

COST COMPARISON, SIX-PHASE CYCLES

Plant size (thousand tons of nitrogen/year)	160	267
Initial investment cost for a single plant plus discounted value of subsequent maintenance and overheads at 5% of investment cost, and replacement assuming 12-year life and 10% discount rate (Rs. millions)	676	966
Discounted value of all future investment, maintenance, replacement, and overhead costs per ton of future nitrogen demand (Rs./ton)	434	378
Discounted value of all future shipping penalty charges per ton of future nitrogen demand (Rs./ton)	3	5
Operating costs for naphtha, fuel, electricity, labor, bags, etc. (Rs./ton)	350	
Ex-factory cost of bagged urea, six-phase cycles* (Rs./ton of nitrogen)	787	733

*These ex-factory costs may be compared with urea's import price of Rs. 1,700/ton of nitrogen.

We have also calculated costs for all combinations of discount rates at 5, 10, 15, and 20 percent per year together with annual demand increments of 10-, 30-, 50-, 70-, and 100,000 tons per year. In all cases except one, the larger plant has an advantage in total costs over the smaller one. The single exception occurs with the combination of a high discount rate (20 percent) and an extremely low demand increment (10,000 tons per year), less than one-third the lowest increment estimated for the locations proposed here. Even for this parameter combination, the cost difference is small. Thus, a different discount rate would not affect our conclusions substantially.

These computations also lead us to believe that the simplifying assumption of equal demand increments for the different areas does not affect the plant size conclusions here. Since the larger plant is found to be more desirable than the smaller one for equal demand increments at the lowest value projected for any area, it is reasonable to conclude that increasing the increments in some areas would make the larger plant even more desirable.

Our computations indicate that there is a strong case for the construction of larger nitrogenous fertilizer plants than those currently being planned for India. India's market is big enough to support plants which range up to the limits of current engineering knowledge. The economic desirability seems evident for developing even larger plants.

[Condensed from "Investments for Expanding the Capacity of India's Nitrogenous Fertilizer Industry," a paper presented at The Institute of Management Sciences, XIV International Meeting, Mexico, August 1967, to appear in a forthcoming issue of Management Science: Application Series as "Capacity Expansion for India's Nitrogenous Fertilizer Industry."]

THE CASE FOR SMALL PLANTS IN INDIA

Phillips Foster and Dennis Wood

[Pre-fabricated, small-scale fertilizer plants could offer significant advantages over large-scale ones. Construction time is shorter, foreign exchange is saved, fewer demands are made on managerial talent, market radius is reduced, and plants achieve full capacity much sooner.]

In this article we explore the economic development implications of the availability of a new generation of small-scale fertilizer plants. These "prefabricated" plants, recently developed by engineers and manufacturers in the U.S., produce urea as an end product; they use reciprocating compressors (as opposed to the centrifugal compressors used in large plants), and off-gas or naphtha as major raw materials. The plant is sometimes called "skid-mounted" because sections of it are prefabricated on I-beams. This permits them to be transported via water, truck, or rail to the desired site, where the sections can be lifted or "skidded" onto foundations. Once in place, comparatively minor assembly readies the plant to produce fertilizer.

The capacity of these plants, about 150 metric tons (MT) of urea per day, immediately suggests their consideration for installation in small countries where the market for fertilizer is too small to justify a large plant. But the speed with which these plants can be put on stream after the order for one is placed may

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also make them attractive to a country like India, with a much larger fertilizer market. The small-scale plants have many economic development advantages over the large-scale plants. Ease of construction is probably the most significant, but there are others.

Market Orientation vs. Input Orientation

In 1967, there were twenty-three nitrogen fertilizer projects in India, typically naphtha-based. [See map, p. 105] Fourteen were located on or near the seacoast. Such a site provides easy access to naphtha either from a nearby coastal oil refinery or by shipment directly from Middle Eastern oilfields. On the other hand, a coastal plant site, regardless of its size, has the disadvantage of enlarging the marketing radius from the plant itself, since the marketing area is necessarily a semi-circle. With an inland location, the marketing area is a full circle.

In order to compare the potential marketing radius from small vs. large (i.e., over 1,000 MT/day) plants, let us assume that within the next few years, with increased availability of fertilizer, Indian farmers will be using N (nitrogen) at the rate of 10 pounds per acre. We can then ask, "What would be the marketing radius if all the cropland adjacent to the fertilizer plant received nitrogen at this rate?" In the case of a small plant producing 21,735 MT of nitrogen per year, the marketing radius from a plant at an interior site such as Lucknow, in Uttar Pradesh (where 86 percent of the land in surrounding districts is cropped), would have to be 53 miles. The marketing radius of the semi-circle serviced by a large coastal plant in Madras producing 152,145 MT per year and selling fertilizer in nearby Andhra Pradesh, Mysore, and Madras states (where 50 percent of the land area is cropped) would have to be 258 miles.

The transportation and marketing problems faced by large-scale input-oriented coastal plants in India are thus formidable. The marketing area must usually extend for hundreds of miles away from the plant site. The sales organization must necessarily be large, and haulage distances, much of them over the already heavily burdened railway system, are correspondingly great. In contrast, small-scale, interior, market-oriented plants might sell all or most of their product within a 50- or 60-mile radius. The sales force could be correspondingly smaller and the transportation problems involved much easier to manage. Conceivably, all or most of the fertilizer could be hauled away from the plant via trucks and bullock carts.

Management and Ownership

Large firms typically require a higher level of managerial talent than small firms. This widely accepted management principle is

amply demonstrated in virtually every country in the world. Experience in the maintenance and management of fertilizer manufacturing plants is scarce in India. It would appear easier and faster to train individuals to run small plants than large ones. Experience in the United States has shown that the small plants have far less down-time than the typical large plant. This comparative ease of maintenance and management should give the small plant an advantage in India.

Because of the compact marketing area possible with small-scale plants, they could readily provide a rallying point for strengthening the local cooperatives. Member purchases that were tied in with ownership of shares in the plant itself could serve as a vehicle for education in capital use and returns to capital.

Ease of Construction

Experience with seven plants in India indicates that five to nine years are required between the time the license is issued and the time a large-scale fertilizer plant is on stream. The Monthly Commentary on Indian Economic Conditions (April, 1966) states that "the time normally required for implementing a fertilizer plant is six years." Plants to produce 160,000 tons N per year were licensed for location in Cochin, Goa, Madras, and Kanpur in September 1964, but as of 1967 very little progress had been made. One reason it takes time to get a large plant on stream is that, after licensing, there is usually a period for designing, subcontracting, and engineering before construction can begin. For the analysis in this paper, we have assumed, optimistically, that these functions will take one year and construction three for a large plant—a total of four years.

Because the small-scale plant is pre-packaged and pre-fabricated, it needs no design phase and much shorter construction time. It seems reasonable to assume that such plants could be on stream in India within 18 months after the contract is negotiated. Plants at Prior, Oklahoma, and Medicine Hat, Alberta, were on stream within six months after the order was placed. Plants at Plainview and Odessa, Texas, were on stream within nine months. Two plants in France and one in Spain went on stream within a year after the order was placed.

Waiting two-and-a-half years longer for a large plant, as opposed to a small one, to go into production involves costs; as will be shown, these costs are sizable and have significant economic development implications. Two of them are strategic and measurable: 1) the interest charge on investment in the large-scale plant during the two-and-a-half years when it is still being built but after the small-scale plant is already on stream; and 2) the cost of the fertilizer and foodgrain which must be imported during the same period.

There are other costs involved in waiting for the large plant to go on stream, but these are difficult to measure in economic terms and are not part of this analysis. One of these other costs could be stated in terms of a lengthening of the time it takes India to achieve its fertilizer and foodgrain production goals. Taking only the two measurable costs, we have attempted to compare the development returns and foreign exchange costs for seven small plants that produce in total as much fertilizer as one large plant.

Net development returns. Assumptions for our analysis were as follows: The large plant costs Rs. 435.4 ($58) million, including import duty of 27.5 percent of value of plant and equipment at port of entry. This cost is 40 percent foreign exchange. [Rs. 7.5 = $1] The large plant requires four years from time of licensing until it goes on stream. Its rated capacity is 178,994 MT of nitrogen per year, and it operates at 70 percent of capacity for the first year, 80 percent the second, and 85 percent in succeeding years, which is considered normal for the U.S. —though one might argue that this is optimistic for India, where such plants typically operate at 60 to 65 percent of capacity. Development costs can be charted as per Table I.

The seven small plants have a total turn-key cost, including import duty and an auxiliary power source, of Rs. 577.5 ($77) million and require one-and-a-half years to go on stream. Their combined capacity is 169,050 MT per year and, because they are relatively simple to operate from the start, they operate at 90 percent of capacity—conservative, since all such plants on stream so far have a history of operating at 100 percent of capacity or more. Thus, these plants produce 152,145 MT of nitrogen per year, or 330,750 MT of urea. This is the same quantity of fertilizer produced by the large plant when operating at 85 percent of capacity. Development costs are shown on Table II. It should be noted that, although the replacement cost is included as a fixed cost per ton in this study, a $3.0 million stock of spare parts would be required for the large plant, whereas a $650,000 stock of spare parts is included in the purchase price of a single small plant. The small plant price also includes a 30-day-supply naphtha storage tank (1.5 million gallons); the large plant price includes a 10-day-supply tank (3.7 million gallons).

In our calculations, the total value of the foodgrain generated by the nitrogen output of one fertilizer plant constitutes the gross development returns from that plant. A pound of nitrogen produces 10 additional pounds of foodgrain such as wheat, which is valued at its import price of Rs. 548 ($73.07) per metric ton. It is likely that the higher foodgrain output generates greater use of labor and other resources, but these indirect returns are not included in this analysis.

TABLE I

DEVELOPMENT COSTS AND RETURNS FOR A LARGE-SCALE PLANT

(Million Rupees)

	1968	1969	1970	1971	1972	1973	1974	1975
Development Returns								
Foodgrains	--	--	--	--	686.622	784.709	833.755	Repeated
Development Costs								
Investment[a]	19.374	58.123	174.368	135.619	--	--	--	--
Interest[b]	.740	2.220	9.621	14.801	--	--	--	--
Domestically produced fertilizer[c]	--	--	--	--	96.312[c]	110.070	116.950	Repeated
Net Development Returns	-20.114	-60.343	-183.989	-150.420	590.310	674.639	716.805	Repeated

[a] Turn-key plant cost less tariff.

[b] Interest at 8.5% on 5% of total investment from initiation of project, 15% one year from initiation, 65% two years from initiation, and on 100% of total investment three years from initiation of project. (Interest included as a cost of production after January 1, 1973.) Dollar interest only is included here since Rupee interest, for India, is a surplus flow.

[c] Rs. 359.59/MT of urea. See p. 116 for components of development cost. These are calculated for operation at 85% of capacity, due to lack of information concerning the impact of different operating capacities on unit costs in India. The total development cost of domestically produced fertilizer in 1972 and 1973 should be somewhat higher than the figures here indicate, if our assumptions of 70 and 80% use of capacity during those years are correct.

TABLE II

DEVELOPMENT COSTS AND RETURNS FOR SEVEN SMALL-SCALE PLANTS

(Million Rupees)

	1968	1969[a]	1970	1971	1972
Development Returns					
Foodgrains	--	416.878	833.755	833.755	Repeated
Development Costs					
Investment[b]	235.548	235.548	--	--	--
Interest[c]	14.388	15.622	--	--	--
Domestically produced fertilizer[d]	--	70.150	140.301	140.301	Repeated
Net Development Returns	-249.936	95.558	693.454	693.454	Repeated

[a] The seven plants are assumed to go on stream July 1, 1969.

[b] Turn-key plant cost less tariff.

[c] Interest at 8.5% on 25% of total investment from initiation of project, on 50% three months from initiation, and on 95% one year from initiation. (Final 5% of investment paid 18 months from initiation of project.) Interest included as a cost of production after July 1, 1969. Dollar interest only is included here since rupee interest is, for India, a surplus flow.

[d] Rs. 432.41/MT of urea. See p. 116 for components of development cost.

We have used the concept of "surplus flow" in determining the development cost of fertilizer production. The real cost of producing fertilizer from the point of view of the Indian economy includes all costs except tariffs, taxes, depreciation, and domestically paid interest and profits. These latter expenses are actually surpluses which are potentially available for other productive uses within the Indian economy. Thus, for purposes of this analysis, the development cost of the fertilizer is calculated by subtracting these expenses from the market, or farm gate, price—here assumed to be Rs. 840 MT, the price set by the central Fertilizer Pool in 1967. Interest paid to foreign financiers is not a surplus, and has been included in the development cost.

We have calculated the present (discounted) value of net development returns for the 25-year period after licensing for one large plant and seven small ones. The licensing date was assumed to be January 1, 1968. Given that it takes the large plant four years to come on stream, the results of this operation show the opportunity cost, or net development returns at present value, of erecting one large plant instead of seven small ones to be Rs. 4, 944 million. The opportunity cost of erecting seven small plants instead of one large plant is Rs. 3, 826 million. Thus, at the time of approval, the net developmental gain from erecting seven small plants instead of one large plant would be Rs. 1, 118 million.

Foreign exchange. From the economic development point of view, there are four categories of foreign exchange costs involved in fertilizer projects such as those being discussed in this paper: 1) fertilizer imported after the plant is licensed and before it goes on stream; 2) foodgrain imported during the same period; 3) imported components of the plant; and 4) interest on the foreign exchange spent on imported components. These foreign exchange costs are likely to be borne by both Indian sources, such as the government of India, and by non-Indian sources, such as an aid-giver like the United States government.

Table III shows foreign exchange requirements in U. S. dollars for the two fertilizer projects compared in this paper. Assumptions pertaining to this table (in addition to those mentioned previously) are as follows: Imported fertilizer costs Rs. 796. 80 ($106. 24) per metric ton. For the large plant, 20 percent (66, 150 MT) of plant output would be imported during each of the first two years, and 40 percent is imported during each of the next two years before the plant goes on stream. After the plant goes on stream, the difference between its output at 85 percent of capacity and its output at 70 and 80 percent of capacity during the first two years of operation will be made up by importing appropriate amounts of fertilizer. For the seven small-scale plants, 20 percent (66, 150 MT) of total output

TABLE III

COMPARISON OF ANNUAL FOREIGN EXCHANGE COSTS FOR TWO FERTILIZER PROJECTS[a]

(Million Dollars)

	1968	1969	1970	1971	1972	1973	1974	1975
Dollar Costs: One Large Plant								
Imported Fertilizer	7.028	7.028	14.056	14.056	5.271	1.757	-	-
Imported Foodgrains	88.926	88.926	66.694	66.694	-	-	-	-
Dollar Investment	1.161	2.322	11.610	8.127	-	-	-	-
Dollar Interest[b]	.099	.296	1.283	1.973	1.747	1.253	.757	.267
Total	97.212	98.572	93.643	90.851	7.018	3.010	.757	.267
Dollar Costs: Seven Small Plants								
Imported Fertilizer	7.028	3.514	-	-	-	-	-	-
Imported Foodgrains	88.926	44.463	-	-	-	-	-	-
Dollar Investment	27.638	27.638	-	-	-	-	-	-
Dollar Interest[c]	1.919	4.309	3.796	2.852	1.914	.978	.136	-
Total	125.509	79.923	3.796	2.852	1.914	.978	.136	-
Small Plant Cost Advantage (Large Plant Costs Minus Small Plant Costs)	-28.297	18.649	89.847	87.998	5.104	2.031	.619	.267

[a] Repair and maintenance are assumed to be covered entirely by Rupee expenditure.
[b] Assume 25 percent of original investment repaid per annum from start-up of plant.
[c] Assume 20 percent of original investment repaid per annum from start-up of plant.

would have to be imported during the time before the plants go on stream. If foodgrain is imported instead of fertilizer, the total amount of foreign exchange required of India and aid-givers for one large plant would increase. Each plant is budgeted to be paying dollar interest on the declining value of its dollar cost for several years after start-up.

On this basis, the small plant will pay for itself by the end of the fifth year of production. (Turn-key cost of one small plant is Rs. 82,510,000, which is equal to the cumulative gross profit at the end of the fifth year of production.) The large plant will pay for itself early in the fourth year of production, but, because it goes on stream after the small plants, it is still paying off its investment one year after the small plant is paid off.

Annual dollar costs for the large plant project are larger than for the small plant project in every year except the first. Total costs for the small plants are $176 million less than for the large plant, mainly because, in the latter case, fertilizer and foodgrain would have to be imported for two-and-a-half years longer. This $176 million is lost to India and aid-givers, and cannot be used for other productive purposes.

[Condensed from "Economic Aspects of Manufacturing Fertilizer in Small Plants in India," University of Maryland Agricultural Experiment Station, College Park, Maryland. Mimeo.]

THE CASE AGAINST TURN-KEY PROJECTS

S. Venkataraman

[Indigenous design and plant manufacture can offer significant advantages to a country like India. With turn-key arrangements, the temptation is to follow developments in industrial countries without full analysis of their implications.]

If India continues to depend on imported fertilizer technology, mainly in the form of turn-key plants, achievements in cost reduction cannot be very significant and the Indian farmer, as well as the economy as a whole, will suffer. This is because, in a plant designed and engineered abroad, the choice among alternatives is invariably made from economic considerations in the country of design, and not from considerations of the real cost to the economy of the importing country. This is where an indigenous process designer or design organization can play a significant role.

First, an indigenous process design organization would be in a position to standardize capacities and design of fertilizer plants, with significant advantage to the economy. Standardization would reduce design engineering and procurement expenses. It would also enable indigenous entrepreneurs to organize themselves more rationally for the manufacture of fertilizer plants and machinery, so that import requirements could be progressively reduced. Standardization would reduce the need for large inventories, since many of the spares could be obtained at relatively shorter delivery time from indigenous

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manufacturers. As a consequence, fertilizer plants could be designed, installed, and commissioned in a much shorter period. Then, as operating experience is gained, cost reductions may be possible by lowering factors of safety consistent with increased experience under local conditions, reducing standby plant and machinery, rationalizing inventory requirements, etc.

The purchase of plant and machinery from a variety of sources on a turn-key basis invariably leads to profligation of the amount and kinds of equipment for which even maintenance spares are not easily available indigenously. On the other hand, an Indian designer can keep in view the availability of indigenous capacities and raw materials while choosing specifications. For example, titanium and stainless steel can both be used as lining material in urea reactors. Even though the life of titanium may be longer than that of stainless steel, the fact that stainless steel will be available indigenously—if not immediately, at least in coming years—should be a consideration in the choice of lining material, even at the cost of slightly increased frequencies of replacement.

Similarly, utilization of indigenous design and engineering capabilities can lead to more rational conclusions on process schemes. For example, data supplied by interested contracting and manufacturing firms has created an impression that, irrespective of locational factors, use of centrifugal synthesis gas compressors would result in significant savings in capital and operating costs in the manufacture of ammonia. But an experienced process designer would, even at first glance, doubt such claims. Centrifugal compressors are known to have lower overall energy efficiency, as compared to reciprocating machines; the lower synthesis pressures inevitable with such compressors is also known to increase energy requirements. Closer analysis would show that the centrifugal compressor alternative invariably uses more naphtha as fuel. A further check would also indicate that a reciprocating compressor, if designed for maximum energy efficiency, can export around 1.8 tons steam per ton of ammonia. If these two factors are taken into account, the choice between the two alternatives would be determined by the relative cost of electricity and fuel. In a typical location, with power from hydroelectric sources and fuel from petroleum sources, the reciprocating compressor is known to show advantage in operating cost of over Rs. 20 per ton of ammonia. [$1 = 7.5 rupees]

The competitive buyers' market in a developed economy requires companies to compete with ever more sophisticated products. In a cost-conscious developing country, however, product specifications must be maintained at the lowest level possible consistent with the minimum requirement of the product. A typical example would be

the biuret content of urea. It is generally accepted that, except for specific folial applications to a few crops, biuret content of up to 1.5 percent does not limit urea's usefulness as a plant nutrient. Quite naturally, the lower biuret content that has been achieved by some advanced methods involves increased initial capital as well as operating costs. In a developing economy, such sophistication in product specification may not be warranted.

Based on the large fertilizer plants that are being set up abroad, whose capacities have been increased mainly to achieve reasonable synthesis pressures with the use of centrifugal machineries, some planners in this country have advocated larger and larger plants in the belief that this will result in reducing the fertilizer costs. But minimizing the delivered cost of fertilizer to the farmer involves two elements: 1) the ex-factory delivery price, and 2) the cost of distribution. While the ex-factory delivery price would naturally come down with an increase in plant capacity, the distribution cost would increase because the product would have to be distributed over a larger area. Optimum plant size varies from location to location; it would naturally be greater in a country like the United States, with a high intensity of fertilizer application, than in India, where the intensities are still low. Furthermore, in the context of India's current level of development, sophisticated mechanization at increased capital cost with a view to reducing labor inputs is not justified. This logical conclusion is often obscured by slogans on labor productivity.

In the choice of basic raw materials for fertilizer production, the temptation is frequently to follow developments in other countries without full analysis of their implications. In any comparative analysis, for example, raw materials like coal, with high incidence of labor input in their cost of production, should have a significantly down-weighted price. On the other hand, naphtha, the production of which is still substantially dependent on the import of crudes, should be priced realistically on the basis of its cost of production to the economy. To use the current artificial formula for pricing naphtha on the basis of pre-devaluation exchange rates [$1 = Rs. 4.75] is unrealistic in the study of alternative feedstocks.

[Adapted from "Cost Reduction in a Developing Economy—Role of Indigenous Process Design," Seminar on Cost and Financing of Fertiliser Projects in India. New Delhi: The Fertiliser Association of India, 1967, pp. 160-168.]

THE CASE FOR IMPORTING AMMONIA AND OTHER INTERMEDIATE INPUTS

J. Chanmugam

[Even for countries where excess naphtha from petroleum refining facilities is available, it would pay to import (cheap) ammonia for making fertilizer and export (more expensive) naphtha.]

The production and consumption of fertilizers of all types have been expanding rapidly since World War II. As of 1966, world consumption, excluding mainland China but including U. S. S. R. and Eastern Europe, of the three main fertilizer ingredients was about 18 million tons of N (nitrogen), about 14 million tons of $P_2 0_5$ (phosphate), and about 11 million tons of $K_2 0$ (potassium).

The growth of world population and the increased demand for food require a drastic increase in fertilizer use, especially in the developing world, in the next decade. Forecasts of future world fertilizer requirements ten years from now vary considerably and there is, of course, a great difference between estimates of potential demand, based on food requirements, and effective demand, taking account of the various problems of accomplishing fertilizer distribution and utilization. Whether the actual consumption growth rate will be 10 percent or 20 percent over the next decade is not so important at the moment as the recognition that, on any reasonable basis, the substantial increases in fertilizer consumption will call for major increases in production facilities. However, present productive capacity is centered in the developed

A second article by Dr. Chanmugam appears on p. 81.

areas—Western Europe, Soviet Russia, U.S., Canada, and Japan—where production is greater than consumption.

In contrast, the developing countries of Asia, Africa, and Latin America, which need fertilizers the most and need them urgently, have been relatively slow in progressing toward adequate production capacity. One reason for this is the shortage or lack of cheap raw materials in many of the countries: hydrocarbons for N, phosphate rock and sulphur for P_2O_5 and potash for K_2O. On the other hand, there are some notable examples of developing countries which have one or more of the raw materials abundantly and cheaply available and greatly in excess of their domestic needs.

Nitrogenous Fertilizers

With regard to nitrogenous fertilizers, for example, the cost of natural gas, the basic hydrocarbon raw material to produce ammonia, would be only $2-4 per ton of ammonia in the Persian Gulf, whereas the equivalent raw material cost using naphtha would be $14-18 per ton of ammonia. With large refrigerated tankers, ammonia could be shipped at least 1,000-5,000 miles before the raw material cost advantage would be eliminated by shipping costs.

This fact has particular relevance to those countries where the domestic fertilizer market would not support what is today considered an economic-sized ammonia plant. Furthermore, many countries without adequate existing or planned refinery capacity would have to rely on imported naphtha (or fuel oil, if new technologies for economic utilization of this feedstock are developed). The import of ammonia obviates these disadvantages, since small-sized units to convert ammonia into solid fertilizer involve relatively small investment and are economically sound.

The use of cheap imported ammonia probably has economic validity even in countries that have or will have refinery facilities capable of producing naphtha in excess of their needs for motor gasoline and is even worthy of serious consideration in countries having markets which can sustain large modern ammonia plants. In most of these countries, refineries are based on imported crude oil and are designed to produce the countries' needs of refined petroleum products, particularly kerosene and diesel oil. These refineries produce a surplus of naphtha. Naphtha is the only source of hydrocarbon for the rapidly growing petrochemical industry, however; in the long run, there will be increasing shortages of naphtha from the refineries in the developed countries, and surplus naphtha from the developing countries could become an important export item, while cheap ammonia could be imported to meet fertilizer needs.

Phosphoric Fertilizers

The situation is not very different regarding P_2O_5. Phosphate rock is found in commercially exploitable quantities only in a few countries: U.S., Morocco, Tunisia, Senegal, Jordan, Oceanic Islands. The most common means of making the P_2O_5 in phosphate rock available to plants in a soluble form is by treatment with sulphuric acid into superphosphate or phosphoric acid. Sulphur to make sulphuric acid is also available only in a very few countries: U.S., Mexico, and from sour natural gas in France, Canada, and Iran. The present worldwide shortage of sulphur relative to demand is expected to continue over the foreseeable future. Because of the high price and the probable shortages, efforts are being made to develop other sources of sulphur, particularly pyrites, but in many of the developing countries the latter development will take many years to come to fruition. An economical course may thus be to make phosphoric acid on a large scale at the source of either the rock or the sulphur and export it to the developing countries.

A concept that may turn out to be of even greater significance in the long run involves the production of elemental phosphorus. Where electric power is relatively abundant and relatively cheap, elemental phosphorus could be produced at competitive costs from phosphate rock. Such elemental phosphorus could then be exported and conveniently and directly converted into phosphoric acid in the recipient country.

Such means of providing P_2O_5 to the developing countries either as phosphoric acid or elemental phosphorus has considerable appeal and could give a significant impetus to increased usage of phosphoric fertilizers in developing countries.

[Based on material presented at various courses of the World Bank's Economic Development Institute by Dr. Chanmugam.]

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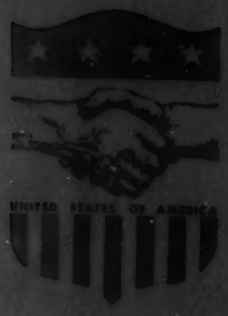
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